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VACUUM JACKETED UMBILICAL LINES TECHNOLOGY ADVANCEMENT STUDY

CENTRAL VACUUM PULLDOWN SYSTEM

AMETEK/Straza
790 Greenfield Drive
El Cajon, California 92021

April 7, 1969

Final Technical Report, Task VI
Contract Number NAS 10-6098

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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This report is one of seven similar tasks related to vacuum jacketed components used on the service arms of the launch umbilical tower at Launch Complex 39, Kennedy Space Center, Florida.

16. Abstract

This report presents results of a study for a central pulldown system to be used on the service arms of the launch umbilical tower at Launch Complex 39, Kennedy Space Center, Florida. Areas studied included hardware evaluation, installation feasibility, product review of presently available vacuum system hardware, state-of-the-art investigation, and design. The design phase was followed by a proposal containing the Test Plan, Procurement Plan, and Cost Summary. (This portion was later cancelled.) An analysis of series and parallel manifold systems was made, and the results were included in this report. The applicability of a vacuum ion pump to maintain high vacuum in the annulus of the jacketed line segment was studied, and it was decided that an empirical evaluation would be necessary before final conclusions could be made. Use of stainless steel for system components that would withstand corrosive atmospheric conditions was recommended.

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Final Technical Report

For

Vacuum Jacketed Umbilical Lines

Technology Advancement Study

Task VI

Central Vacuum Pulldown System

Contract Number NAS 10-6098

April 7, 1969

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6.0 ABSTRACT

This document presents the results of the Phase I Study Program for a central vacuum system. Areas of study covered were hardware evaluation and installation feasibility at Complex 39, Cape Kennedy Space Center, product review of presently available vacuum system hardware, a state-of-the-art investigation, and a design phase. The design phase was followed by a Phase II Proposal which contains the Test Plan, Procurement Plan and Cost Summary.

Presently, there is no central vacuum system at Complex 39 and the hardware evaluation was limited in scope, relating mostly to spatial consideration for installation feasibility. Company experience with vacuum manifold systems is drawn on for empirical aspects of the evaluation. Some common articles to a central system such as valves, vacuum monitoring devices and manifold lines are reported in detail of Task II, Task V and Task VI of the study program. It is concluded that if a central system is desirable, tower space is available.

Several different systems were considered during the study. These were:

A. Single station concept.

B. Multistation system.

C. Vacuum for pumps integral with the vacuum lines.

D. Vacuum for pumps coupled with absorption pumps.

An analysis was made of parallel and series manifold systems. From a safety point of view, the parallel system is better with isolation valves at each line segment.

In the design phase, a complete analysis is made of the multistation and single station system. Results of this analysis shows that a single station system is impractical from the manifold size requirements and length of pump down required for line segment remotely located from the pump station. Consideration is also given to a vacuum instrumentation system tied to the umbilical tower's logic block for launch control monitoring of propellant loading readiness prior to launch. A state-of-the-art investigation is made for the applicability of a vacuum ion pump to maintain high vacuum in the annulus of the jacketed line segment. While feasible, an empirical evaluation is considered necessary before any final conclusion can be made.

Any central system would have to be made up of components resistant to the corrosive atmosphere found at Cape Kennedy. Design material for components would be 300 series stainless steel.

The preliminary Phase II Plan consists of the test plan including evaluation of vacuum ion pumps and a procurement plan. Task VI was cancelled at the end of the Phase I Study Program.

6.1 HARDWARE EVALUATION

6.1.1 Functional Review

Most of the propellant loading swing arm lines on the launch umbilical towers at Complex 39, Saturn V are vacuum jacketed to prevent excessive loss of the cryogen propellant or excessive temperature rise of the propellant (liquid hydrogen and liquid oxygen) during propellant loading operations. For a vacuum jacketed line to function efficiently during propellant loading operation, the annulus pressure of the swing arm line should be at 0.1 micron or less. Presently, this pressure is obtained by two (2) means:

A. The line is preconditioned at the manufacturer by long pumping of the annular space at the same time applying heat to drive off the gasses contained on the surface of the annular space.

B. Gettering material such as Zeolite or charcoal is applied to the cryogen surface of the annular space to capture residual gas molecules during loading operations.

After installation of a vacuum jacketed line at Complex 39, Kennedy Space Center, any loss of vacuum requires that the annular space be repumped to a value within the capability of the getter material to reduce that pressure by cryopumping to a value of 0.1 micron or less. This loss of vacuum can occur for a variety of reasons such as:

A. Leakage caused by accidental penetrations of the annular envelope.

B. Leakage through seals or components common to the vacuum annulus.

C. Replacement of components such as thermocouples.

D. Insufficient preconditioning of the vacuum annulus during manufacturing.

E. Human error causing loss of vacuum in the annular space.

Any of the above necessitates a repumping of the annular space after repairs are made or the replacement of the faulty line segment. Presently, at Complex 39, this repump is accomplished by semi-portable pumping stations. Due to the location of the swing arm lines on the launch umbilical tower, this is a costly, time consuming operation. An alternate solution to this operation is the installation of a central vacuum drawdown system with all vacuum jacketed line segments manifolded to a common pumping station. Several advantages would be obtained from a central drawdown system; preconditioning of the lines would not be necessary, lines could be readily repumped prior to launch dependent on system efficiency, no gettering material would be necessary and leak checking of suspected line segments would be simplified. The main disadvantages would be the additional equipment required to be maintained and the attendant lowering of reliability by the increased number of components.

A tour of the launch facility was made to study the feasibility of a central system installation from the point of view of space requirement, since no system is presently employed. Space availability is a prime consideration for any such installation. The conclusion of this study was that it would be feasible to make space available for a central drawdown system. Figures 1 through 3 depict the swing arms with propellant lines installed and show the critical space limitation.

The components of any central drawdown system would be exposed to the corrosive atmosphere found at Cape Kennedy and to the high shock and vibration levels during launch. Therefore, the system would have to be constructed of material resistant to salt corrosion and resistant to shock and vibration.

It is concluded that the central drawdown system is feasible for installation at Complex 39. Such an installation would facilitate the repump of line segments with excessively high annulus space pressure. With such a system, line pressures could be easily maintained. The addition of such a system would affect overall reliability with more components and maintenance.

6.1.2 System Operating Requirement

The central vacuum drawdown system should have the capability to maintain all service arm propellant lines at a launch ready vacuum level with a capacity to repump any line segment to 0.1 micron or better. Ideally, a single pumping station would be provided for the hydrogen propellant system and a single station for the oxygen propellant systems.

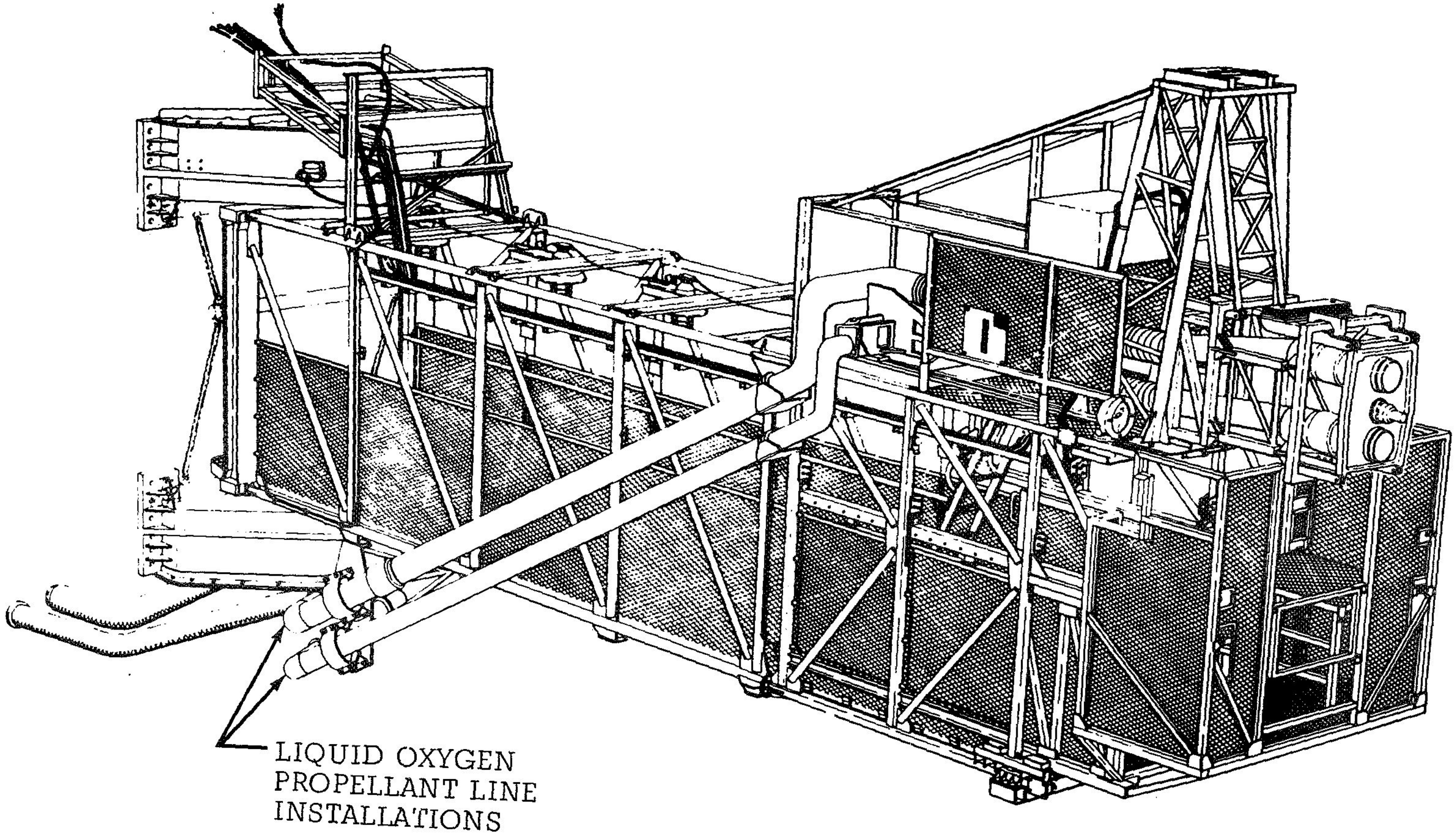

Figure 1. S-IC Intertank Service Arm Assembly

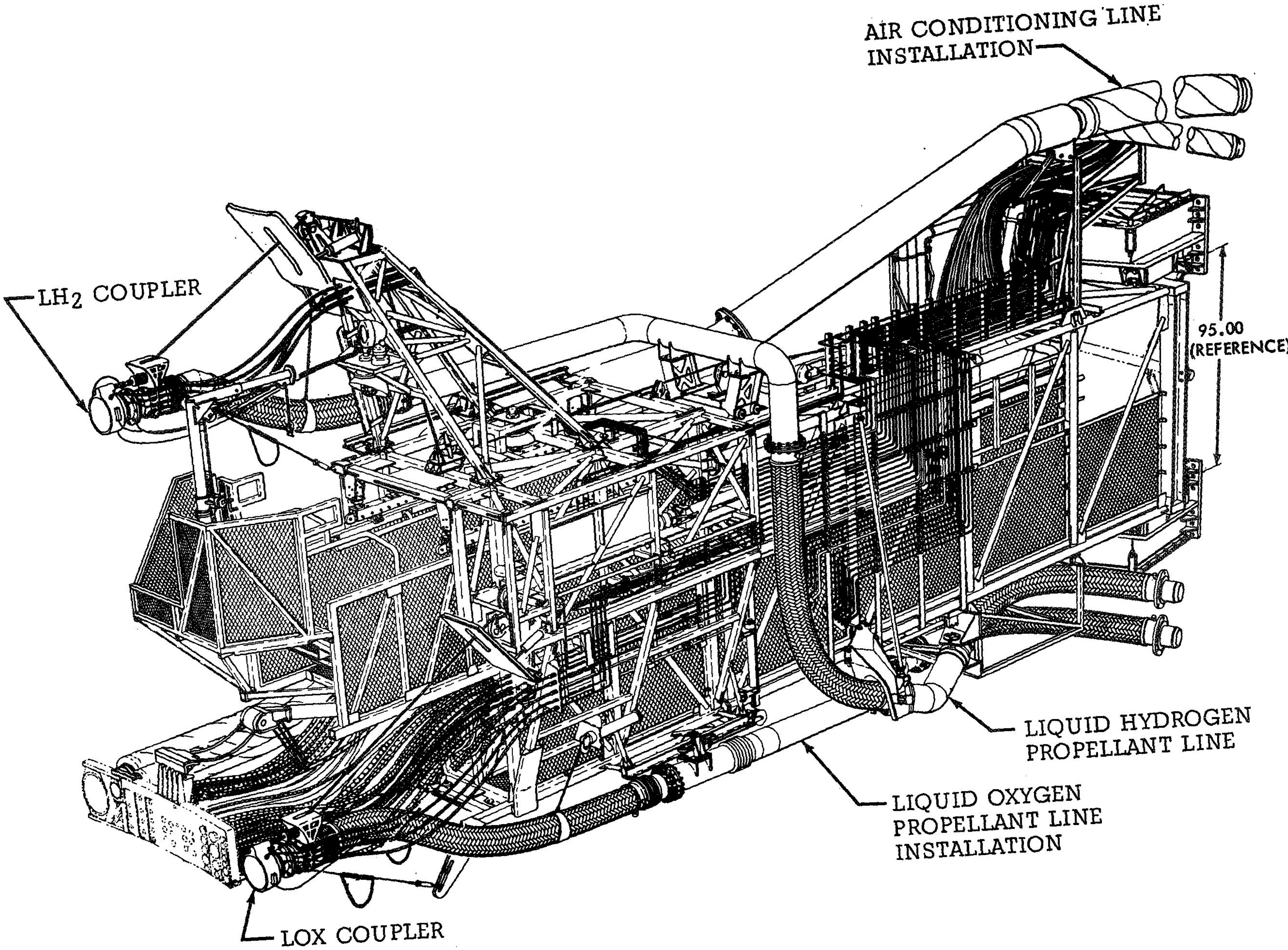

Figure 2. S-II Intermediate Service Arm

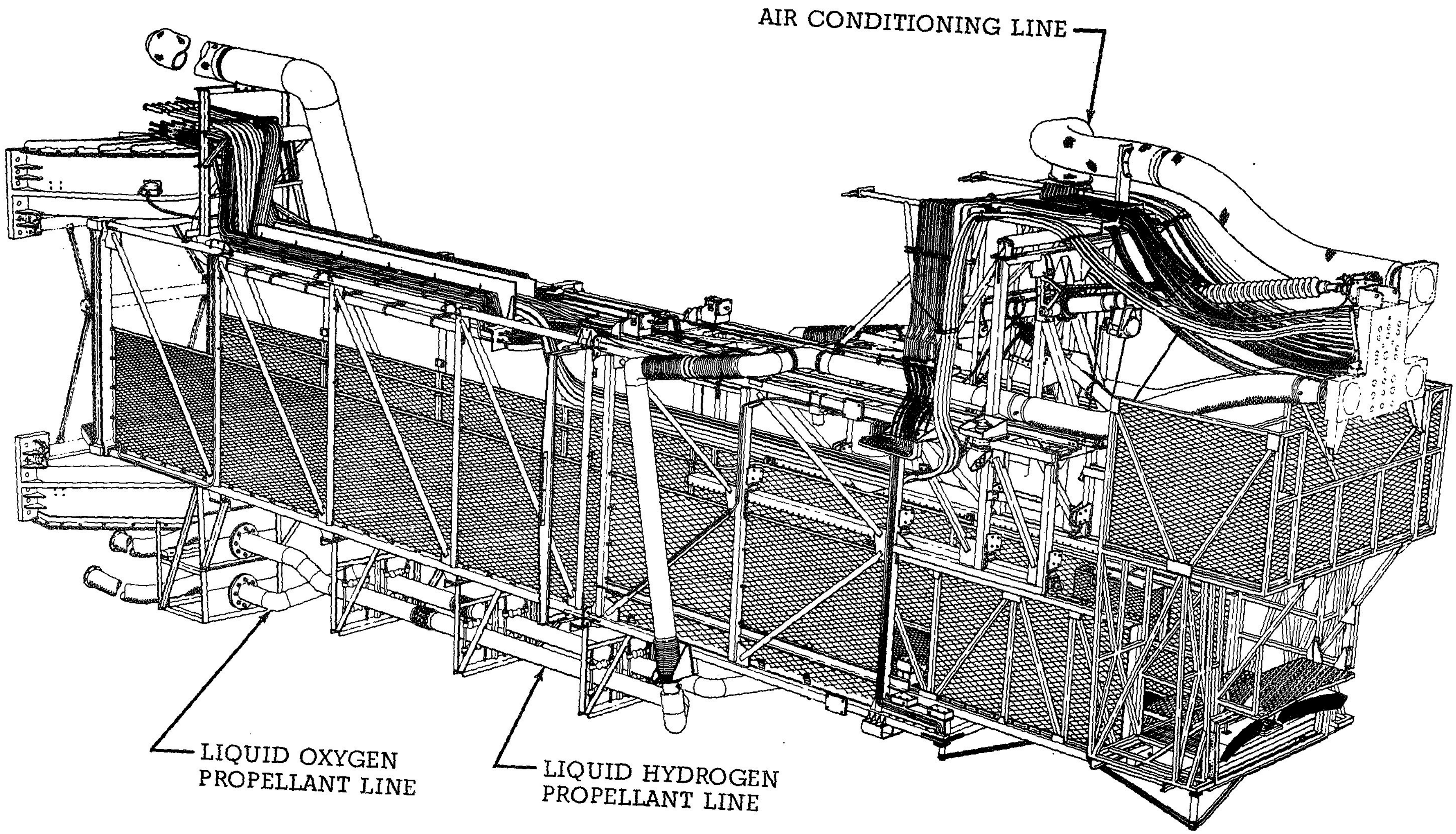

Figure 3. S-IVB Aft Service Arm

This system would consist of the following basic components:

A. Isolation Valves

B. Manifold Lines

C. Pressure Sensors (Thermocouples)

D. Pumping Stations
   (1) Diffusion Pump
   (2) Mechanical Pump
   (3) Cold Trap (water cooled)
   (4) Associated Valving

All of the components listed are readily available and could be procured to meet the established requirements. (See Design Section).

An isolation valve would be located at each line segment to be opened or closed at the pumping station as desired. These valves would be of the fail closed type in case of power failure or pump failure. These valves should be located as close as possible to the line segment and could replace the present hand operated seal off valves.

The manifold would consist of flexible sections where required and hard lines where deflection is no problem. The manifold could be of the series or parallel type for a particular swing arm. (See Figures 4 and 5.) A disadvantage of the series system is system vacuum is lost if any down stream line segment is faulty. In both the series and parallel systems, a manifold would eventually tie all line segments to a pumping section.

Pressure sensing devices such as thermocouple probes would be located at each line segment to indicate annular space pressure. These sensors could be readout at the pumping station or possibly through a "go - no-go" system at the launch tower logic block. The "go - no-go" system would allow monitoring of the propellant line fill readiness at the launch control console.

A conventional pumping station would be the means for system evaluation. This pumping station consists of a mechanical roughing and foreline pump, a diffusion pump, a water cooled baffle, and associated valving. Such a system would be fully automated with a single push button operation, sequencing the unit through the proper operating cycle. Any power failure would automatically close down the system. In conjunction with the

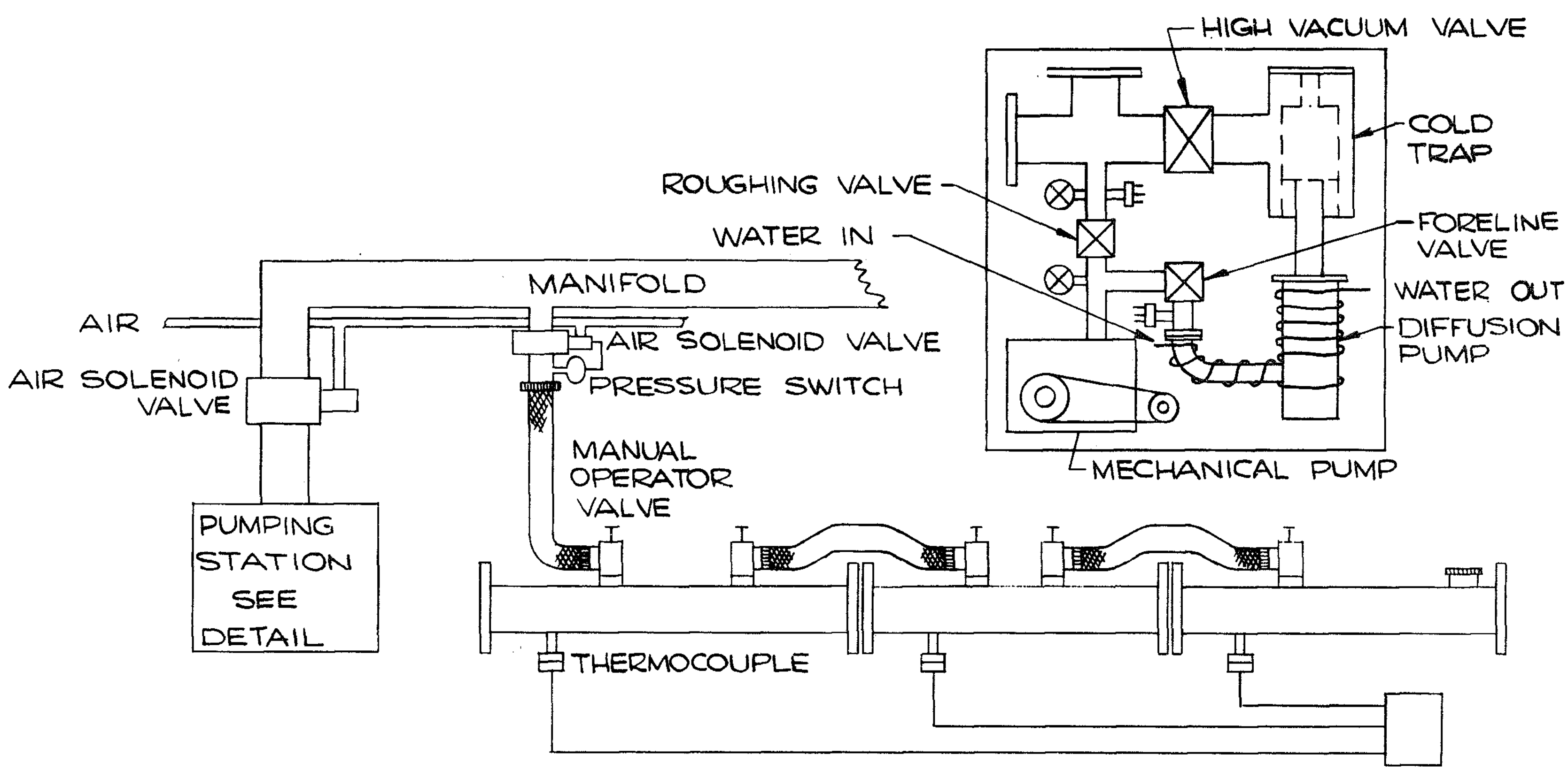

Figure 4. Single or Multiple Station System Series Hookup

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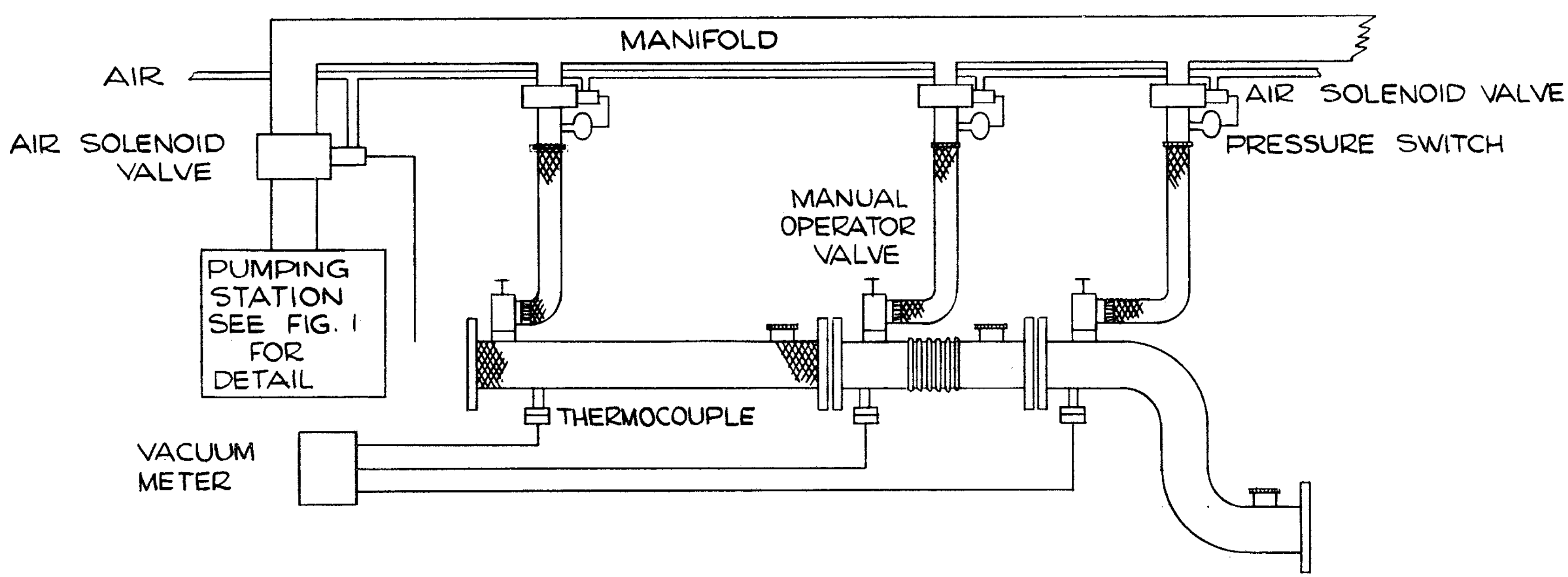


Figure 5. Single or Multiple Station System Parallel Hookup

4055-2

pumping station, a panel should be provided to allow closing and opening of isolation valves as desired for pumping of line segments. A readout meter should be provided to allow monitoring of line segment annulus pressure.

Maintenance of conventional pumping station should be minimal, primarily that of replacing diffusion pump oil. Company experience with pumping stations indicates that a direct drive system instead of belts should be incorporated to drive the mechanical roughing pump. To withstand environmental conditions, components should be constructed of corrosion resistant material such as 316 series stainless steel.

It is envisioned from a safety standpoint that a separate system would be provided for the oxidizer and the liquid hydrogen propellant lines. Safety precautions also dictate that the central vacuum drawdown system would be secured at some set time prior to launch.

6.1.3 Evaluation of Equipment

Existing locations of the propellant lines on the swing arms make it extremely difficult for any repump operations. A central pumpdown system would eliminate the necessity of moving pumping stations to the required level on the launch umbilical tower for each repump activity. Also, a central system with centralized readout stations would eliminate the need for connecting a portable readout meter periodically for the purpose of monitoring the annulus vacuum level.

In the event of a suspected leak, a helium mass spectrometer could be connected directly to the manifold system for determination of the location of the leak.

Since there is no central system presently installed, a direct evaluation of the equipment performance cannot be made, however, AMETEK/Straza has operated two vacuum manifold systems successfully over a period of three (3) years. The systems consist of a manifold line 40 feet long and seven inches in diameter. Two (2) four inch diffusion pumps backed by 15 CFM mechanical pumps provide pumpdown capability. Eight (8) outlets with bellows seal type valve allow attachment of line segment to be evacuated. Provisions are made for reading pressure level in the manifold. The following is a detailed description of the two pumping stations:

A. Station #1 Components

(1) One (1) - 7 inch diameter manifold

(2) Eight (8) - 1 1/2 inch diameter bellows type vacuum valves (NRC)

(3) Refrigerated water cooling system

(4) Two (2) - Model 3305 NRC portable pumping stations

a. Welch type 1397B mechanical pump 15 CFM

b. NRC (Norton) 161 (NS4-750) multi-stage 4 inch diffusion pump

c. NRC (Norton) 315-4 cheveron cryo-baffle, water cooled

d. NRC (Norton) 1277 4 inch manually operated slide valve

e. Thermocouple/Ionization gauge control NRC 710B

f. Associated valves

B. Station #2 Components

(1) One (1) - 7 inch diameter manifold

(2) Eight (8) - 1 1/2 inch bellows seal type valves

(3) Refrigerated water cooling system

(4) Two (2) V.J.C. Model CS4 pumping stations (components basically the same as Station #1)

These two stations have performed successfully on a continual basis for the past three (3) years with minimal maintenance being required. Failures of the bellows seal valve have occurred six (6) times during this period and the heating elements of the diffusion pumps have failed twice. The bellows seal valves have been operated through hundreds of cycles as line segments are added and removed from the manifold. The other mode of system failure is the wearing of the mechanical pump drive belts which is a routine maintenance problem, although it does indicate a direct drive between the motor and the pump is desirable. One pumping station is located outside with no special environmental protection.

From the successful performance of AMETEK/Straza vacuum manifold systems, it is concluded that such an application is feasible at Cape Kennedy with precautions taken to minimize the effects of the corrosive atmosphere found there. Such a manifold system would reduce hardware malfunction (propellant line) by reducing the number of installations and removals required with attendant reduction in the possibility of line damage during these operations. Flex lines in particular, are prone to damage during these operations. A study made of the damage frequency of the vacuum jacketed flex lines revealed that 26 failures were reported for 81 flex lines.

6.1.4 Review of Conditions and Failures

Since a central vacuum drawdown system does not exist, conditions known to be the required environment for Complex 39 launch umbilical tower systems are applied for consideration of conditions and failures. Such a system would be exposed to the corrosive atmosphere found at the Space Center. Also, it would have to be able to withstand the shock and vibration encountered during launch. Components presently used at the Cape, common to a vacuum drawdown system, such as seal off valves (isolation valves), pressure sensing devices, and flexible lines reported in detail in Sections II, III and V of this study program, indicated reliabilities of 0.9913, 0.8400, and 0.6790 respectively. No reliability figure can be derived from this data since damage due to installation of the flex lines cannot be isolated, although the normal approach would be to assign a reliability figure as a product of the components. The equation for the central vacuum appears as follows:

R (Sys) = R (Flex Hose) x R (Seal Off Valve) x R (Vacuum Probes) x R (Pump Station).

By the very purpose of a central drawdown system, a number of the reported failures would be cancelled by the installation and operation of the system. Flexible portions of the manifold would be smaller and lighter than the heavy propellant line segments reducing chances of installation or removal damage.

In conclusion, even though no reliability figure can be derived for a hypothetical central drawdown system operating at Cape Kennedy, it is expected the actual down time and turn around repair time would be reduced, since normal maintenance would keep the central vacuum system operational and the central vacuum system would serve as a tool to expedite and/or eliminate V.J. line repair problems.

6.1.5 Review of Test Data

Review of failures of company owned manifold vacuum systems down time in operation continually for three (3) years, except for maintenance, shows that bellows type seal off valves have failed six (6) times and the heating coils of the diffusion pumps have failed twice. It is noted that the bellows valves fail in a closed position with no loss of pressure in the vacuum system. Maintenance has been limited to mechanical pump belt replacement and diffusion pump oil changes. No failures have occurred due to system leaks. An approximation can be made for system reliability. Assuming valve replacement and repumping takes four (4) hours, replacement of heating elements requires two (2) hours and maintenance (belt replacement) requires two (2) hours per month, total down time for the two (2) systems has been as follows:

		Hours
6 (valve failure) x 4	=	24
2 (heating element) x 2	=	4
2 (maintenance two systems) x 24	=	48
Total down time	=	76

Total hours of operation is 46,000 for two (2) systems

$$\text{Reliability} = \frac{76}{46,000} = 0.9984$$

A preliminary reliability goal is established by using the products of the reliability components common to the system. The preliminary reliability of a central drawdown system is:

R (Sys) = R (Flex Hose) x R (Seal Off Valves) x R (Vacuum Probes) x R (Pump Station) = (0.9900) x (0.9953) x (0.9644) x (0.9984) = .9487

While there are some reservations about the exact validity of the reliability figure, it does indicate a reasonable goal to strive for.

6.2 PRODUCT REVIEW

6.2.1 State-of-the-Art Investigation

A review was made of available literature for methods of obtaining vacuums in the range of interest for this study program. Most material was obtained from the following books:

A. "Scientific Foundation of Vacuum Techniques", by Saul Dushman

B. "Vacuum Technology and Space Simulation", by Holkeboer, James and Pagamo

C. "High Vacuum Engineering", by Vance

D. "Applied Vacuum Engineering", by Vance

E. "Applied Cryogenic Engineering", by Vance

In general, the review is limited to pumping devices, since detailed analysis of other components are reported in other parts of the study program. The review includes the following types of pumps:

A. Mechanical

B. Diffusion

C. Ion

D. Absorption

E. Sublimation

Many types of mechanical pumps are available, but the study was limited to the standard rotary vane type to be used in conjunction with a diffusion pump. Basically, the mechanical pump is an oil filled device with an inlet and outlet port. In operation, the rotor mounted eccentrically on the driving shaft rotates to open a sliding valve to the space to be exhausted allowing gas to fill the volume between the eccentric rotor and the pump housing. As the rotor turns eccentrically around the housing of the pump, the valve to the vacuum space closes and the trapped gas is expelled through the outlet port. To prevent condensible vapors from contaminating the oil, a gas ballast valve is available which admits atmospheric air during part of the cycle preventing the condensation of the condensible vapors.

Mechanical pumps are made in many sizes and are of proven reliability. Normally, the pumping speed begins to fall off at approximately 100 microns, although final blank off pressures of 0.1 micron can be obtained with the better pumps. If such pumps are used alone to obtain high vacuums, a baffle or trap should be used to prevent back streaming of oil into the vacuum annulus eventually "poisoning" the gettering material.

Other types of mechanical pumps are roots, jet pumps and molecular.

A diffusion pump works on the principle of a heavy vapor, normally oil or mercury to trap gas molecules in the vacuum system. A typical pump consists of a water cooled housing containing a multistage jet, an oil reservoir, and a heater. In operating, the heater raises the oil temperature until a stream of vapor is sent up the jet stack. The jet in turn directs the oil vapor outward and downward toward the cool walls of the pump. The oil vapor entrains gas molecules and carries the captured molecules downward to the reservoir as the vapor is cooled by the water jacketed housing. A foreline mechanical pump removes the entrained gas molecules as the oil is reheated and vaporized. Operation is continuous. Pumping speeds are generally not effective above 100 microns and must be used in conjunction with a mechanical roughing pump. Pumping speed is fairly constant below one (1) micron.

Pumps are classified as to diameter and normally are made in even multiples, i.e., 2 inch, 4 inch and 6 inch diameters. Pumps up to 48 inches in diameter are readily available.

A typical diffusion pump system includes a roughing and foreline pump, foreline, valve, roughing valve, a high conductance gate valve to the vacuum system, and a pressure monitoring system.

Ion pumps produce high vacuums by permanent removal of gas molecules and atoms by chemical association or burial. In operation, high voltage DC from a power source is applied to the annode producing free electrons, which are spiralled by means of a magnetic field to increase chances of collision with gas molecules or atoms. Such collisions cause ionization of the molecules, which are attracted to the cathode causing sputtering of the titanium element. These sputtered atoms are deposited on the annode. Chemically active gasses, such as nitrogen and oxygen are combined with the continuous fresh supply of titanium at the annode to form stable chemical compounds while the inert ionized gasses are attracted to the cathods and are buried there. The systems' pressure is directly portional to the current drawn by the ion pump. The higher the pressure the higher the current. At very low pressures (0.1 micron or better) the vacuum ion pump has a relatively long life. Above this pressure, its life is greatly shortened. Because of the relationship of current to pressure, a vacuum ion gage can be used as a vacuum gage to indicate system pressure relieving the requirement for an extra sensing device. Also, leakage can be detected as a sudden increase in current required. A vacuum system should be pumped to a value of one (1) micron or better before an ion pump is activated.

The sublimation pump operates on the principle of heating a titanium element to a temperature which effects the sublimation of the titanium. The fresh titanium is deposited on surrounding cool surfaces and form stable chemical compounds with chemically active gasses such as oxygen, nitrogen or hydrogen. The sublimation pump is limited in the fact it does not capture the chemically inert gasses such as helium or argon. Rate of disposition is controlled by the current, which is normally constant and pumping speed is related to the disposition area and the conductance of the gas from the vacuum space into the disposition area. Pumping speed is the greatest at lower pressures. Sublimation pumps have a predictable life knowing the amount of titanium available and the rate of sublimation. These pumps are normally used in conjunction with ion pumps during the initial pumpdown to speed gas molecule or atom capture. Sublimation pumps are made with replaceable elements as the titanium is used up during operation. Again, as with ion pumps, fairly low pressures (0.1 micron or better) are necessary before efficient operation is obtained. Because of the limitations, sublimation pumps would have limited application as part of a pumpdown system for swing arms at Cape Kennedy.

Sorption pumps basically are cryopumps containing a gas absorbent (gettering) material contained in a bath of liquid nitrogen. In operation, the unit is filled with LN_2 and allowed to stabilize. The sorbent in contact with the cold surface exposed to the LN_2 is capable of sorbing relatively large amounts of gas. The sorbent material is zeolite or other similar molecular sieve. Better vacuum pressures are obtained by the use of sorption pumps in stages with pressures of 1.0 micron obtainable. Such a device would be useful where an accumulated gas load from minor leakage is desired to be removed. The gas pumped by the sorption pump is not permanently removed from the vacuum system, but is released as the molecular sieve returns to room ambient temperature. Also, the pump has definitive capacities depending on the amount of molecular sieve available. During normal operation, the pump is reactivated by disconnecting it from the vacuum system and heating the unit to drive off the accumulated captured gasses.

In conclusion, aside from the conventional mechanical/diffusion pump system, the ion pump and sorption pump show some promise of application as pumpdown devices at Complex 39, Cape Kennedy. However, evaluation would have to be made of these devices.

6.2.2 Hardware Investigation

Manufacturers of vacuum systems were contacted to procure literature on vacuum systems and components. Those contacted are as follows:

A. Aero Vacuum Corporation

B. Andar Corporation

C. Benco Incorporated

D. Consolidated Vacuum Corporation

E. Denton Vacuum

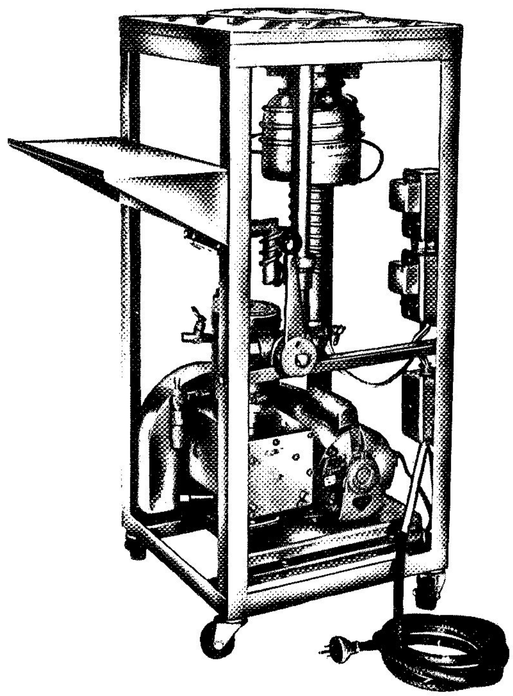
F. General Electric Vacuum Division

G. Heraeus - Englehard
H. High Voltage Engineering Corporation
I. Kinney Vacuum
J. Norton Corporation
K. Sunbeam Vacuum Furnace
L. Stokes Company
M. Ultek - Perkins Division
N. Vactronics Laboratory
O. Vacuum Industries, Incorporated
P. Vacuum Instruments Corporation
Q. Varian Associates, Vacuum Division
R. Veeco
S. Cryolab
T. Cooke Vacuum
U. Granville - Phillips
V. Edwards High Vacuum
W. Hughes Vacuum Division

Catalogs and brochures are extensive with only a partial inclusion of available products included in the report as a representation of products. Nearly all of the equipment available is of high quality stainless steel construction. Each product represented is for informational purposes only. (See Pages 18 through 77 .)

Several companies were visited with good results. These were General Electric, Vacuum Instrument Corporation, Consolidated Vacuum Corporation (now Bendix Vacuum Division), Varian and Ultek - Perkins which primarily manufacture vacuum ion pump systems. The personnel contacted were very cooperative and gave freely of their time. General Electric, Bendix Vacuum Division and Varian have strong quality control groups while others furnish control as necessary. Varian and Bendix Vacuum Division appeared to be the most alert to advances in the art with Varian practicing in production those steps such as prior baking of raw materials, internal welds wherever possible to produce reliable vacuum systems.

Varian and Ultek-Perkins were contacted in particular to review the feasibility of the use of vacuum ion pumps in swing arm propellant line application. While both companies considered the application feasible, both felt an actual test evaluation would have to be made since so many variables were present. These variables are efficiency of initial bakeout and pumpdown, outgassing rates of super insulations such as mylar and conductance of a vacuum jacketed line.



L2D and L4D Diffusion Pump Carts

GENERAL DESCRIPTION

The Kinney Models L2D and L4D Mobile Diffusion Pump Carts are capable of obtaining an ultimate pressure in the 10^{-7} torr range. Model KDP high speed diffusion pumps backed by Model KCV vane-type mechanical pumps are mounted in mobile, open frames. Model KWB water cooled baffles above the diffusion pumps improve performance and effectively eliminate diffusion pump backstreaming. Quick acting isolating butterfly valves between baffle and base plate serve as the main isolation valves. A 3-way ball-type roughing and backing valve in each model allows the diffusion pump to be by-passed for roughing and prevents out-of-sequence valving. Nickel plated base plates with gauge connections, necessary manifolding, and air admittance valves complete the system.

Both models feature (1) shelf for a vacuum gauge, (2) vacuum gauge connections, (3) silver soldered manifold joints to assure tight connections, and (4) quick-disconnect manifold couplings for ease of servicing. These units attain 1×10^{-4} torr in less than 3 minutes and 5×10^{-5} torr in less than 5 minutes (including roughing time). Ultimate pressure is 2×10^{-6} torr; pressures of 5×10^{-7} torr are possible using a model KDB liquid nitrogen baffle accessory in place of the water-cooled baffle.

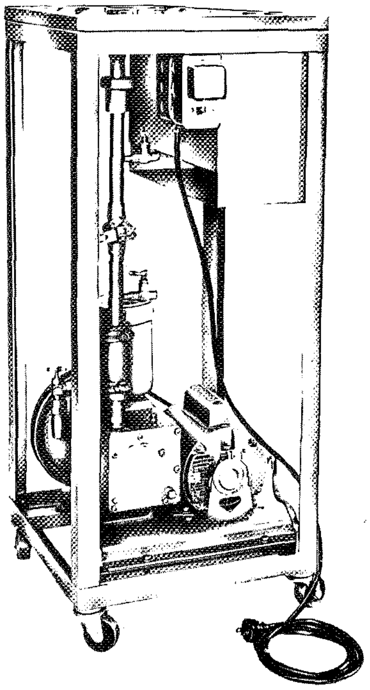
SPECIFICATIONS

	Model L2D	Model L4D
Mechanical Pump Model	KCV-2	KCV-5
Mechanical Pump Displacement	2.3 cfm	4.4 cfm
Diffusion Pump Model	KDP-2	KDP-4
Diffusion Pump Speed at 10^{-4} torr	250 l/s	675 l/s
Water Cooled Baffle Model	KWB-2	KWB-4
Operating Voltage	115 v	115 v
Cooling Water	6 gph	15 gph
Vacuum Gauge Connections: Thermocouple	⅛″ NPT	⅛″ NPT
Ionization	¾″ Compression Fitting	
Base Plate, Nickel Plated	15″ sq.	20″ sq.
Maximum Bell Jar Diameter	14″	18″
Height to top of Base Plate	3′	3′-6″
Width (without shelf)	15″	20″
Depth	15″	20″

ACCESSORIES

Model KTG Thermocouple Gauge
Model KDG Discharge Gauge
Model KDB Liquid Nitrogen Baffle to replace Water Cooled Baffle
Electrical Feed-throughs
Mechanical Rotary Motion Feed-throughs

Figure 6. Vacuum Pump Assembly (Kinney) With Diffusion Pump



L2M Mechanical Pump Cart

GENERAL DESCRIPTION

The Model L2M Mechanical Pump Cart offers a practical, low cost means of obtaining a working vacuum in the 1 to 10 micron range. The components, consisting of a 2 cfm Model KCV-2 vane-type pump, a 15″ square nickel plated base plate, and a ¾″ ball-type isolation valve with manifold, are all mounted within a 15″ square open frame for accessibility. Casters permit the unit to be rolled about easily.

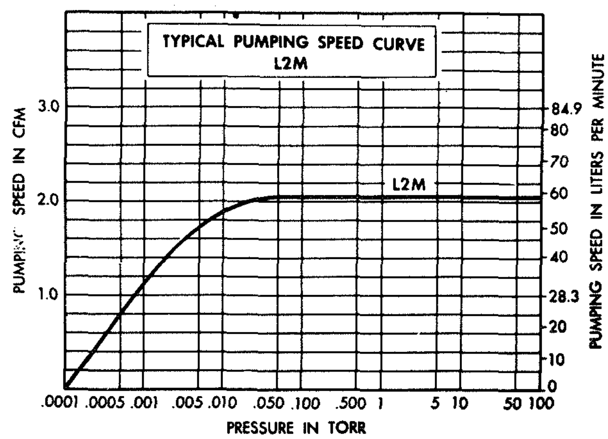
The unit features (1) quick-disconnect coupling in the manifold for ease of servicing, (2) shelf for a vacuum gauge, (3) air admittance valves for the pump and base plate, (4) flexible connector between the pump and manifold, (5) silver soldered manifold joints, and (6) vacuum gauge tapped hole in the base plate.

ACCESSORIES

Impregnation Chamber
Liquid Nitrogen Cold Trap
Model KTG Thermocouple Gauge
Electric Base Plate Feed-throughs
Mechanical Rotary Motion Feed-throughs

SPECIFICATIONS

Mechanical Pump Displacement	2.3 cfm
Operating Voltage	115 V
Motor	¼ hp
Cooling	Air
Base Plate, Nickel Plated	15″ sq.
Vacuum Gauge Connection	⅛″ NPT
Ultimate Pressure (McLeod Gauge)	0.2 micron
Maximum Bell Jar Diameter	14″
Height to top of Base Plate	3′
Width	15″
Depth	15″



KINNEY VACUUM DIVISION®
THE NEW YORK AIR BRAKE COMPANY
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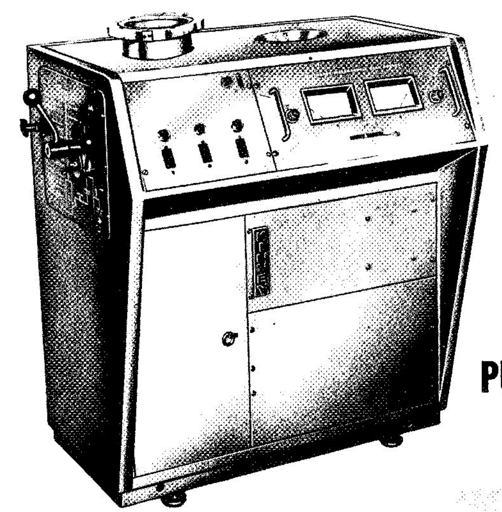
Figure 7. Mechanical Vacuum Pump Assembly (Kinney)

4010.1
CATALOG BULLETIN

KINNEY VACUUM



HIGH VACUUM PUMPING SYSTEM

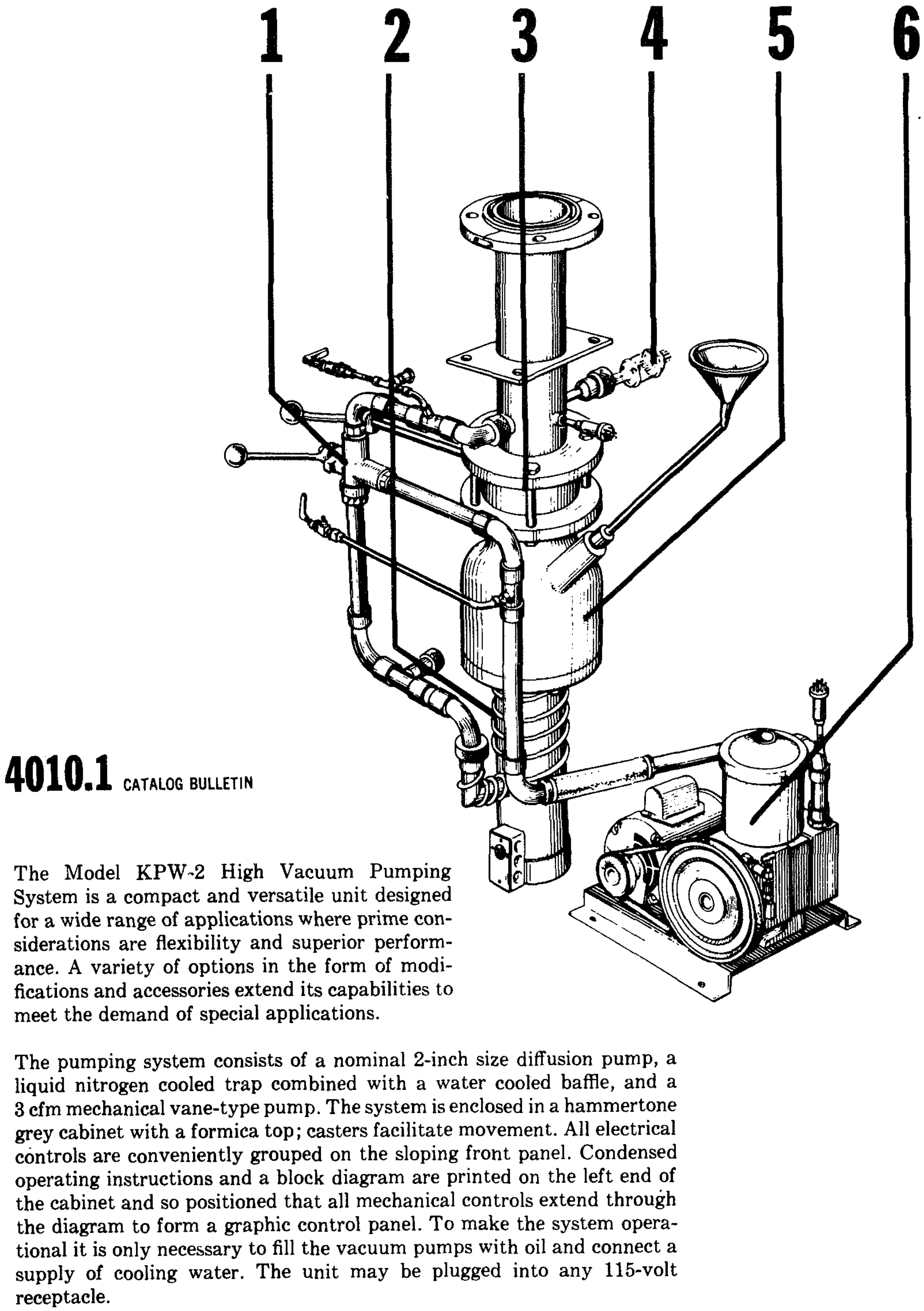
KPW-2

FEATURING

Complete Pumping System in one package
Simplified Operation
100 liters per second pumping speed at inlet connection — Ultimate pressures as low as 5 x 10^{-7} torr
Easy-to-fill cold trap
Ionization and thermocouple gauges
Combined roughing and backing valve
Quiet operation — Low maintenance

MARCH, 1963

Figure 8. Vacuum Pump Assembly (Kinney) With Cutaway of Pumping Assembly and Description of Features (Sheet 1 of 4)



4010.1 CATALOG BULLETIN

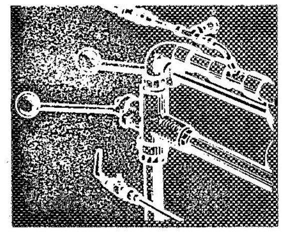
The Model KPW-2 High Vacuum Pumping System is a compact and versatile unit designed for a wide range of applications where prime considerations are flexibility and superior performance. A variety of options in the form of modifications and accessories extend its capabilities to meet the demand of special applications.

The pumping system consists of a nominal 2-inch size diffusion pump, a liquid nitrogen cooled trap combined with a water cooled baffle, and a 3 cfm mechanical vane-type pump. The system is enclosed in a hammertone grey cabinet with a formica top; casters facilitate movement. All electrical controls are conveniently grouped on the sloping front panel. Condensed operating instructions and a block diagram are printed on the left end of the cabinet and so positioned that all mechanical controls extend through the diagram to form a graphic control panel. To make the system operational it is only necessary to fill the vacuum pumps with oil and connect a supply of cooling water. The unit may be plugged into any 115-volt receptacle.

Figure 8. Vacuum Pump Assembly (Kinney) With Cutaway of Pumping Assembly and Description of Features (Sheet 2 of 4)

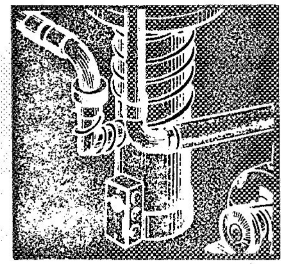
1

ROUGHING-BACKING VALVE: The roughing and backing valves have been combined into one 3-way ball-type valve. Not only is operation simplified, but out-of-sequence operation is prevented. A closed position between the roughing and backing positions seals-off all of the ports on the valve. The seal between the ball and the body is formed by teflon gaskets for durability and freedom of maintenance.



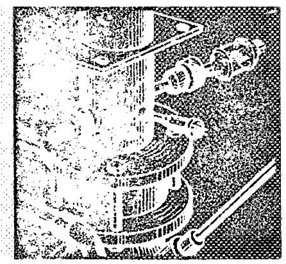
2

DIFFUSION PUMP: The Model KDP-2 Diffusion Pump is designed for dependability, maintenance-free service and maximum pumping capacity (250 liters per second) in the high vacuum range. Its rapid heating and cooling times contribute greatly to shorten operating cycles, and the simplicity of the jet construction permits quick removal for cleaning. Ultimate blank-off pressures as low as 1×10^{-8} torr may be obtained on this pump when mated with the Model KDB-2 liquid nitrogen cooled baffle.



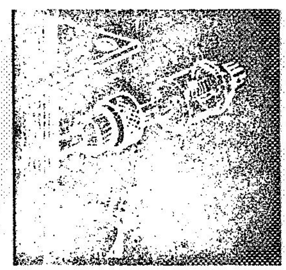
3

MAIN VALVE: The Model KBV-2 aluminum butterfly valve features high conductance, small surface area exposed to vacuum, quick acting operation, simple mechanism, ease of operation, and positive sealing against atmospheric pressure. It serves as an isolation valve for the pumping system permitting the connected system to be opened to atmosphere while pumping system remains in stand-by operation.



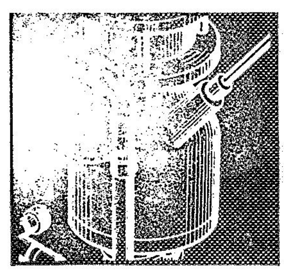
4

VACUUM GAUGE: The Model KITG Ionization-Thermocouple Gauge is a hot filament ionization gauge and a thermocouple gauge combined into one unit. It measures pressures between 3000 microns and 1 micron on the thermocouple gauge, and from 1 micron to below 2×10^{-8} torr on the ionization gauge. Separate meters permit simultaneous readings of both gauge circuits. The discharge gauge tube and one thermocouple gauge tube are located in the neckpiece below the inlet connection; the second thermocouple gauge tube is located adjacent to the mechanical pump suction connection.



5

DUAL-COOLANT BAFFLE: The Model KDB-2 baffle is a high conductance (220 liters per second), optically dense, anti-creep baffle containing an integral water-cooled deflection disc below the baffling surface. Its large liquid nitrogen cooled cryogenic surfaces effectively eliminate diffusion pump backstreaming.



6

MECHANICAL PUMP: The Model KCV-3 compound-type, oil-sealed, rotary vane pump is characterized by quiet, dependable operation, lack of vibration, and complete elimination of smoke. It roughs the system to the cut-in pressure of the diffusion pump — then, backs the diffusion pump while it is operating. Gas ballasting, a highly effective method of eliminating condensable vapors, is a standard feature of this pump. The KCV-3 with 1/4 HP motor has a rated displacement of 3.2 cfm at 646 rpm. It blanks-off at 20 microns or less, with full gas ballast flow.

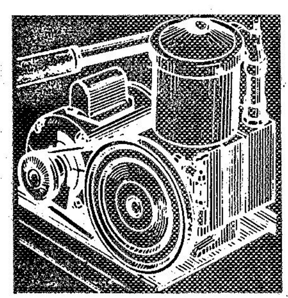
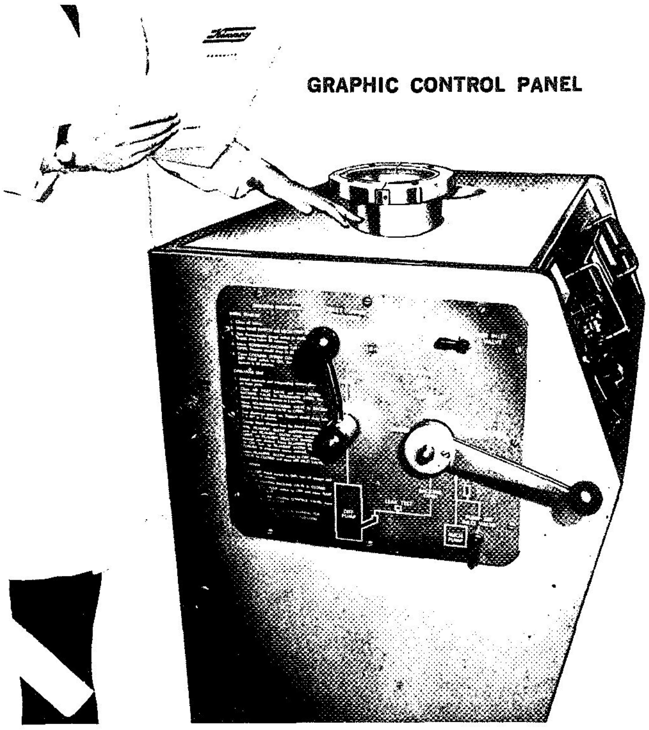


Figure 8. Vacuum Pump Assembly (Kinney) With Cutaway of Pumping Assembly and Description of Features (Sheet 3 of 4)



OPTIONAL ITEMS

- A Kinney Model KCV-5 vane-type 5 cfm pump substituted for the 3 cfm Model KCV-3.
- 4½-liter ballast tank and holding valve to hold the diffusion pump under vacuum during long roughing cycles. A third thermocouple gauge tube is included in the ballast tank and connected to the gauge control.
- Low water flow safety switch connected into the cooling water line to automatically shut off the diffusion pump heater if the flow of cooling water fails.
- Valve connected into the vacuum manifold for the connection of a leak detector.
- Evaporator Assembly — Includes 15″ diameter by ¾″ thick stainless steel base plate with six ¼″ low-voltage feed-throughs and one blanked-off ¾″ hole, and 12″ by 12″, 12″ by 18″, or 14″ x 24″ Pyrex bell jar.
- Hoist for Evaporator Accessory Bell Jar.
- Guard for Evaporator Accessory Bell Jar.
- Adapter to convert inlet connection for use with ½″, ¾″, or 1″ O.D. glass tubing.
- Right Angle Inlet Adapter for horizontal inlet connection.
- Packaged Power Supplies (see catalog bulletin 3900.1).

SPECIFICATIONS

100 liters per second pumping speed at inlet connection; ultimate pressure of 5 x 10^{-6} torr without liquid nitrogen, 5 x 10^{-7} torr with liquid nitrogen.

1″ copper vacuum manifold — permanent joints silver soldered — major components connected to manifold by O-ring sealed compression fittings.

KPW-2 requires approximately 2 KVA of 115-volt power and 1/10th gpm of cooling water.

Approximate Weight: 325 lbs.

Overall dimensions:
42½″ high to top of inlet connection
38″ to top of cabinet
21⅝″ deep
32½″ wide cabinet
35¾″ wide including control handles

Mechanical Pump: 3 cfm vane-type Kinney Model KCV-3

Diffusion Pump: 250 liter-per-second Kinney Model KDP-2

Vacuum Gauge: Combination ionization gauge and thermocouple gauge, Kinney Model KITG-2P.

Main High Vacuum Valve: Aluminum butterfly valve, Kinney Model KBV-2.

Fully leak and performance tested prior to shipment.

Complete with vacuum pump oils, operating instructions and power cord for connecting to standard 115-volt receptacle.

Caster mounted cabinet for mobility.

KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY ® 3529 WASHINGTON STREET • BOSTON 30 • MASS.

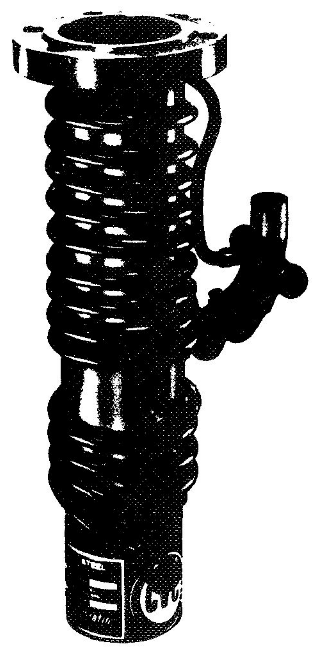
Figure 8. Vacuum Pump Assembly (Kinney) With Cutaway of Pumping Assembly and Description of Features (Sheet 4 of 4)

BULLETIN 6-91

NEW 2-INCH BLUELINE PUMP, type PMCS-2C

FEATURES

- MOST CONSERVATIVELY RATED PUMPS IN THE INDUSTRY
- HIGHEST THROUGHPUT . . . SHORTER TIME CYCLES
- FASTER WARM-UP . . . QUICKER COOL-DOWN
- CONSISTENT PUMP-TO-PUMP PERFORMANCE
- PERFORMANCE UNAFFECTED BY NORMAL VARIATIONS IN POWER
- FLAT SEALING SURFACE FOR CON-O-RING ® GASKETS OR METAL GASKET
- SUITABLE FOR ULTRA-HIGH-VACUUM APPLICATIONS



GENERAL

PMC BlueLine Pumps, the most conservatively rated in the industry, have high throughputs, fast startups, and high plateau speeds. Machined nozzles assure dependable performance . . . eliminate pump-to-pump performance variations. Patented boiler design provides smooth, steady generation of vapor regardless of power variations. For highest overall performance, install a PMC BlueLine pump in your vacuum system.

INDUSTRY'S MOST CONSERVATIVELY RATED PUMPS

CVC pump speeds are based on McLeod gauge pressure readings. CVC's standard McLeod gauges used in pump performance tests are built so that at a pressure of 1 x 10^{-4} torr the error due to dimensional tolerances does not exceed $\pm 1\%$. Speed measurements based only on ionization gauges can be in error by as much as 20 to 30%, unless the electrical gauge and sensing tube are calibrated on the test system against a McLeod gauge.

SHORTER CYCLES INCREASE PRODUCTION

PMC BlueLine pumps reduce cycle time by giving the combined advantages of shorter warm-ups, decreased pumpdown time, and shorter cool-downs. In any production operation these advantages automatically increase your production and savings.

Shorter pumpdown times are achieved by the high throughput and reliable plateau speed of BlueLine pumps. Throughput, the mass-flow rate of gas through the pump, is the true measure of the ability of the pump to do work. Throughputs up to 100% greater than those of comparable-size pumps provide shorter pumpdown time through the 0.3 to 1 x 10^{-3} torr transition range. The high throughput in-

Consolidated Vacuum Corporation

Figure 9. Diffusion Pump (CVC) With Description of Performance and Features (Sheet 1 of 4)

sures the successful handling of larger gas loads and process pressure bursts.

The patented boiler design of these pumps minimizes eruptive boiling and pressure bursts. No splash baffle is needed to keep hot liquid out of the nozzle assembly. Vertically finned heater tubes extend upwards from the bottom of the pump and through the surface of the pump fluid. This patented* design provides at least twice as much heated surface area as is available in comparable pumps using plate-type heaters. Therefore, for a given heat transfer to the pump fluid, a lower watt density can be used. A more efficient heat transfer results in a steady, sustained pumping with no pressure bursts. Air speed of the pump is insensitive to normal power variations.

Cool-down time is shortened by the quick-cool coils on the boiler. This permits the pump fluid to be exposed to atmosphere in less time without danger of decomposition.

*U.S. Patent No. 2,943,783—2,943,784

HANDLE GAS BURSTS EASILY

PMC pumps handle a greater amount of gas than any other pump of comparable size because of their higher throughput capacity. Due to this higher capacity, a given surge in process gas load will result in less increase in system pressure and more rapid pressure recovery.

The system load determines the operating pressure which will be reached with the pump. The higher throughput capacity is illustrated in Fig. 1 below. With a given system gas load Q_1, the throughput of the pump determines the base pressure (P_1 for BlueLine pumps; higher pressure P_1' for other pumps). If the gas load increases, as frequently happens in a vacuum system during process operation, the new gas load (Q_2) is handled more easily by BlueLine pumps. The system pressure increases less ($P_2 - P_1$ for BlueLine; $P_2' - P_1'$ for others).

CLEAN SYSTEM—BACKSTREAMING REDUCED

The backstreaming during pumpdown is reduced by the high throughput characteristic of BlueLine pumps. As little as one half the time is spent in the 0.3 to 1 x 10^{-3} torr transition region during pumpdown. This reduces the backstreaming during pumpdown through this region by up to 50%.

CONSISTENT PUMP-TO-PUMP PERFORMANCE

Precision machined nozzles virtually eliminate the pump-to-pump performance variations characteristic of pumps using spun nozzles. Machined parts produced on automatic machinery provide smooth precise nozzle contours having the fine surface finish required to reduce vapor turbulence and provide a dense, steady, well-directed stream of high-velocity vapor.

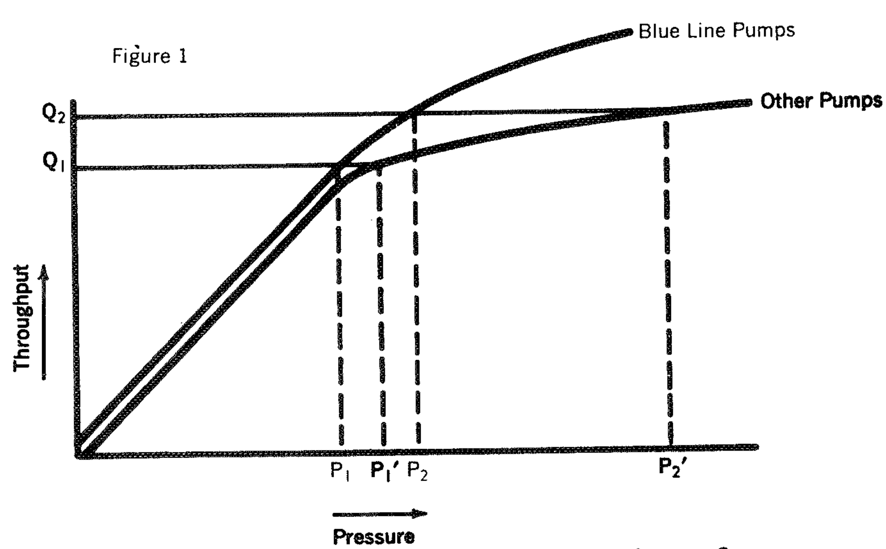


Figure 9. Diffusion Pump (CVC) With Description of Performance and Features (Sheet 2 of 4)

OPERATIONAL DATA

Typical Air Throughput in Pumpdown Range . . . 0.45 torr-liters per second @ 2 x 10^{-2} torr with 5 cfm backing pump

Normal Operating Range . . . . Steady state—below 1 x 10^{-3} torr

Plateau Speed . . . . 104 liters per second (Air) 120 liters per second (Hydrogen)

Recommended Forepump . . . . 1-5 cfm

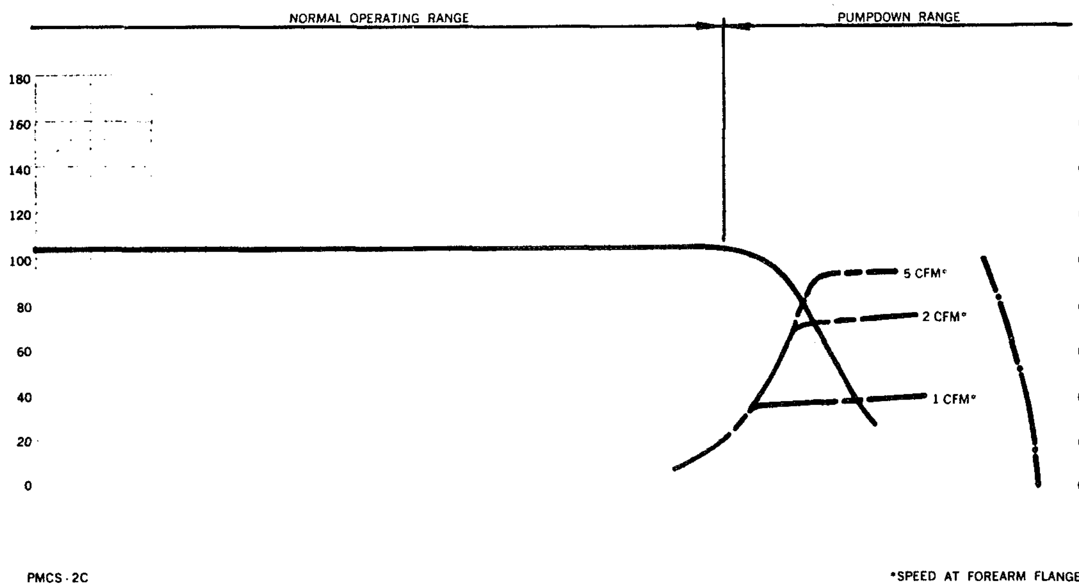
Start-Up Time . . . . 5 minutes

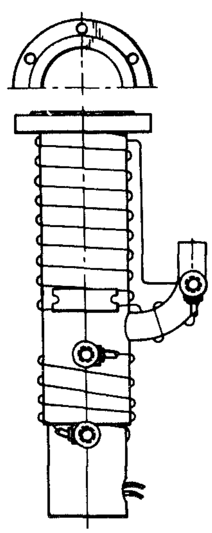
Nominal Cooling Water Temperature . . . . 20° C inlet, 45°-55° C outlet

Rate . . . . 1/5 gallon per minute

Pump Fluid . . . . 80 cc. Convoil-20 is recommended general purpose fluid. Silicone fluid, Convalex-10, etc. can be used

*All data obtained with Convoil-20 pump fluid.





Inlet Connection	Flange	Outlet Connection	Tubing
O.D.	4"	O.D.	3/4"
I.D.	2 1/4"	I.D.	5/8"
Thickness	21/32"	Thickness	—
Bolt Circle	3 5/16"	Bolt Circle	—
No. of Holes	6	No. of Holes	—
Hole Diameter	11/32"	Hole Diameter	—
Gasket Surface I.D.	2 1/4"	Gasket Surface Width	—
Gasket Surface Width	5/16"		

Cooling Connections . . . . 1/8" FPT
Nozzle Material . . . . Aluminum
Casing Material . . . . Stainless Steel
Heater Voltage . . . . 115-Volt, Single-Phase*
Heater Wattage . . . . 300 Watts
Net Weight . . . . 5 lb.
Shipping Weight . . . . 7 lb.
*230-Volt, Single-Phase Heater Available on Request.

Figure 9. Diffusion Pump (CVC) With Description of Performance and Features (Sheet 3 of 4)

BlueLine pumps operate successfully with the commonly used diffusion pump fluids (except mercury). Pumps are factory cleaned and bagged . . . ready for immediate use. Ungrooved flanges simplify interconnection of components . . . no overlapping gasket grooves. Small mechanical pumps provide adequate backing in low throughput applications.

CVC's new seal design, featuring a raised gasket-seating surface and Con-O-Ring gaskets, offers many advantages. The raised gasket-seating surface eliminates the problem of overlapping gasket grooves which require special adapters and prevents the trapping of atmospheric gases which may be released from such grooves into the vacuum system. Soft metal gaskets can be used for ultra-high-vacuum applications . . . for general use, CVC offers the Con-O-Ring, a new concept in elastomer gasketing. It features automatic location of the gasket on the seating surface and limits compressibility in accordance with good vacuum practice. Buna-N elastomers in aluminum retainer rings are standard, but Viton-A elastomers are available on request. The new flanges can be connected directly to the grooved flanges on older CVC valves and baffles.

BlueLine pumps are simple to maintain at peak performance. Only 1¾ inches clearance is needed below the pump to permit heater replacement without removing the pump from the system. Nozzle assemblies are easily removed from the casing for cleaning and replaced without special indexing.

A line of matching valves and baffles is available from stock at Consolidated Vacuum for use with 2-inch PMC pumps. All use ungrooved flanges and Con-O-Rings to eliminate component matching problems. These components are briefly described below; complete details are given in CVC Bulletin 10-1.

A 2-inch VCS-type gate valve with a choice of manual throttling, manual quick-acting, or pneumatic operator is available. These high-conductance, full-opening valves have continually been used in systems with a base pressure as low as 1×10^{-8} torr. VCS valves have high-density, non-porous cast bodies and interior surfaces with an average finish of 100 micro-inches RMS which is two to three times as smooth as other aluminum gate valves.

Three high-conductance chevron baffles are available for use with the 2-inch PMC pumps. The BCR-21A is an ambient-cooled type designed to reduce backstreaming and back-migration of pump fluid without auxiliary cooling. The 2-inch multi-coolant baffle, type BC-20A with stainless steel housing, is a two-part baffle with an insert which can be removed for cleaning without breaking the vacuum line connections. It is recommended specifically for use with water cooling or Freon refrigeration. The similar type BCN-20A has a large reservoir for use with liquid nitrogen. Automatic level sensors and fillers are available for long periods of unattended operation when liquid nitrogen is used.

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Rochester, N. Y., 1775 Mt. Read Blvd., GL 8-2550 Bell & Howell GmbH, Consolidated Electrodynamics Division, P. O. Box 345, Friedberg (Hessen), West Germany, Telephone: (06031) 3441 Bell & Howell Ltd., Consolidated Electrodynamics Division, Lennox Road, Basingstoke, Hants., England, Telephone: 3681.

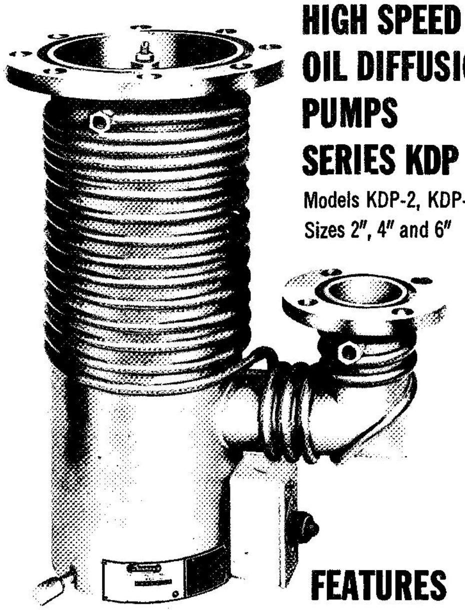
Figure 9. Diffusion Pump (CVC) With Description of Performance and Features (Sheet 4 of 4)

3300.1
CATALOG·BULLETIN

KINNEY VACUUM

HIGH SPEED OIL DIFFUSION PUMPS SERIES KDP

Models KDP-2, KDP-4, KDP-6
Sizes 2", 4" and 6"



FEATURES

Ultimate pressures as low as 4 x 10^{-7} torr untrapped and 1 x 10^{-8} with Model KDB Baffle used with liquid nitrogen.

Largest inlets of any comparable Diffusion Pumps on the market.

Corrosion-resistant aluminum jets.

Non-corroding nickel-plated steel casing with brazed copper cooling coils.

Simplicity of jet construction permits quick removal for cleaning.

Intake and exhaust flanges made with 150 lb. A.S.A. flanges.

Faster heating and cooling times shorten operating cycles.

Low silhouette makes possible a more compact, highly efficient straight-through pumping system.

No foreline trap required.

GENERAL DESCRIPTION

The new KDP Series of KINNEY Oil Diffusion Pumps is noteworthy for utmost dependability, freedom from maintenance problems and maximum pumping capacity in the high vacuum range (below 1 x 10^{-6} torr). Their greatly improved performance is due to fundamental design advances which include: increased inlet diameter, improved heaters, more efficient chimney design and other structural improvements.

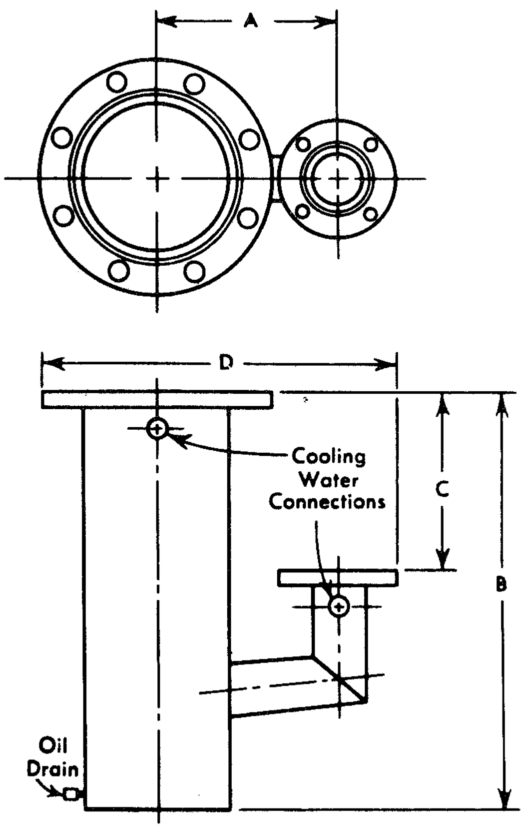
Especially noteworthy is the improved heating and diffusion of oil vapors. Finned heater wells on the 4 and 6 inch models speed up heat transfer from heaters to pump fluid and vapor. Four easily removable cartridge type heaters extend above the surface of the pump fluid to heat the vapors as well as the fluid. The central heater has a high heat conductance rod extending to the top of the chimney to superheat the vapor, thus improving pumping efficiency and reducing back-streaming.
The 2-inch model utilizes an external heater with high conductance heat transfer sleeves extending into the jet structure.

The KDP Series Pumps require no control transformer; they are not sensitive to voltage variations within ±10% of the rated voltage. They are supplied with three-prong plug and socket mounted on a knock-out type receptacle box; the Pump may be permanently wired, if so desired. Heaters on the 4" and 6" pumps can be readily connected to the plug for operation from either 115 or 230-volt line; the 2" pump must be ordered for either 115 or 230-volt operation.

ACCESSORIES

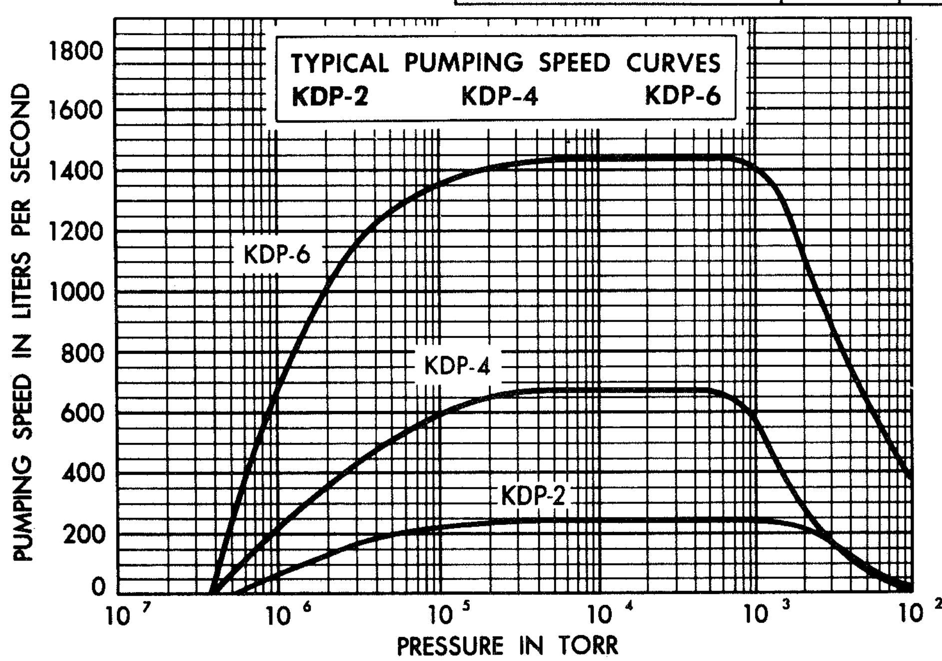
KINNEY Series KWB water or Freon cooled Baffles and KDB Dual-Coolant Baffles are available for use with the KDP Diffusion Pumps.

Figure 10. Diffusion Pump (Kinney) With Description of Performance (Sheet 1 of 2)



SPECIFICATIONS

	KDP 2	KDP 4	KDP 6
SIZE	2"	4"	6"
DIMENSIONS — INCHES A	4¼"	7"	8½"
B	14"	15"	19½"
C	5"	5½"	8½"
D	8¼"	13 13/16"	17"
INLET FLANGE:			
O.D.	6"	9"	11"
I.D.	3"	5¼"	7⅛"
Thickness	9/16"	9/16"	11/16"
Bolt Circle	4¾"	7½"	9½"
No. Holes — Straddle ℄	4	8	8
Size	11/16"	¾"	⅞"
O-Ring Size	No. 340	No. 435	No. 443
EXHAUST FLANGE:			
O.D.	HIGH VACUUM COM-PRESSION FITTING FOR 1⅛" O.D. TUBING	4⅝"	6"
I.D.		1¾"	2⅝"
Thickness		7/16"	9/16"
Bolt Circle		3½"	4¾"
No. Holes — Straddle ℄		4	4
Size		⅝"	¾"
O-Ring Size		No. 330	No. 337
COOLING WATER CONNECTIONS	⅛"	¼" NPT (FEMALE)	
JET MATERIAL	ALUMINUM		
CASING MATERIAL	CARBON STEEL – NICKEL PLATED		
COOLING COIL MATERIAL	COPPER		
UNTRAPPED UNBAFFLED — RANGE	3.7×10^{-7} to 2×10^{-3} torr		
UNTRAPPED UNBAFFLED — MAX. SPEED	250 lps	675 lps	1440 lps
MAX. FOREPRESSURE — MICRONS	400	350	350
PUMP FLUID — TYPE	DC-704	DC-704	DC-704
PUMP FLUID — QUANTITY	130 cc	300 cc	500 cc
COOLING WATER @ 20°C	1/10 gpm	¼ gpm	½ gpm
RECOMMENDED FOREPUMP	KCV-3	KC-8	KD-30
OPTIMUM HEAT INPUT	0.5 kw	1.2 kw	1.6 kw
WEIGHT — POUNDS	17	27	57.5



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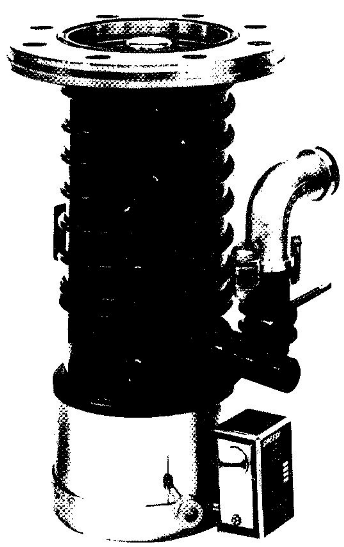
THE NEW YORK AIR BRAKE COMPANY

Figure 10. Diffusion Pump (Kinney) With Description of Performance (Sheet 2 of 2)

EDWARDS

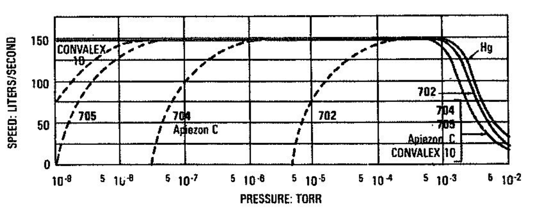
MODELS E02 AND EM2 VAPOR DIFFUSION PUMPS AND ACCESSORIES



150 liters/second • 10^{-10} torr

- **LOWEST OBTAINABLE ULTIMATE VACUA**
  Vacuum brazing at 1000°C assures crevice-free internal construction; freedom from weld decay, flange distortion, structural stresses; positive cleanliness.
- **LOWEST BACKSTREAMING RATE**
  The original cooled guard ring (Model E02).
- **FULLY FRACTIONATING**
  Multi-stage self-purifying jet assemblies.
- **CONSISTENT PERFORMANCE**
  Precisely machined jet assemblies.

SPEED CURVES



SPECIFICATIONS

Stages, E02	4
Stages, EM2	3
Working fluid, E02	oil
Working fluid, EM2	Hg
Fluid charge	25-125 ml
Min. backing-pump displacement	35 l/m
Backing pump recommended	ES 35
Backing connection	1/2" coupling
Cooling-water connection	1/4" O.D.
Min. cooling-water flow at 15 C	0.4 l/m
Heater loading	350 W
Material, E02 body	stainless steel
Material, E02 interior	aluminum alloy
Material, EM2 throughout	stainless steel

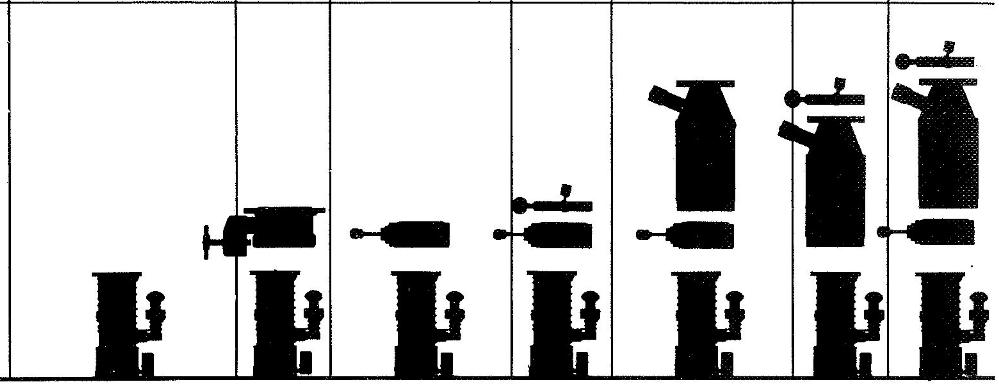
Product integrity is built into every Edwards pump by use of the most modern manufacturing techniques. And Edwards design provides many features and benefits in addition to the following:

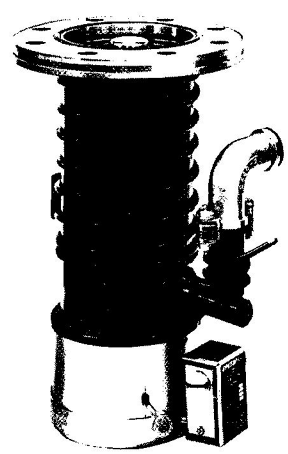
- Mercury pumps of stainless steel throughout; oil pumps have stainless steel body, aluminum-alloy interior.
- Performance maintained with any type of fluid.
- Vacuum O-rings or metal wire seals.
- Fully sealed top jet cap and interior assembly.
- Ejector stage for high critical backing pressure and self-purification.
- Easily accessible fluid-drainage system.
- One-piece heater quickly demountable for maintenance.
- Foreline connection.
- Accessories are interchangeable, require no adapters or mounting brackets.

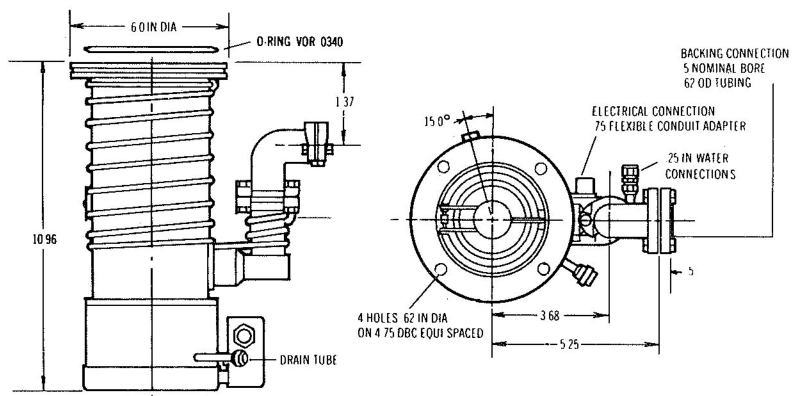
Figure 11. Diffusion Pump (Edwards) With Performance Data (Sheet 1 of 2)

PERFORMANCE DATA

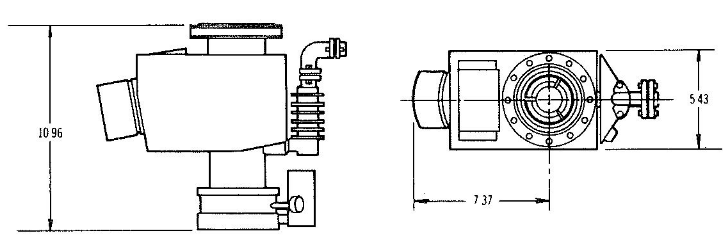
FLUID	BACK-STREAMING RATE MG/MIN CM²	CRITICAL BACKING PRESSURE (TORR)	ULTIMATE VACUUM — TORR (BETTER THAN) A	B	C BAKED SYSTEM	D	E	F BAKED SYSTEM	G	H
SILICONE 702	0.005	0.7	5×10^{-6}	5×10^{-6}	5×10^{-6}	5×10^{-6}	10^{-7}	—	10^{-7}	10^{-7}
SILICONE 704	0.004	0.5	5×10^{-7}	5×10^{-8}	3×10^{-8}	3×10^{-7}	3×10^{-8}	10^{-10}	10^{-7}	10^{-7}
SILICONE 705	0.002	0.35	5×10^{-7}	3×10^{-8}	10^{-9}	3×10^{-7}	3×10^{-8}	10^{-10}	10^{-7}	10^{-7}
CONVALEX 10	0.002	0.25	5×10^{-7}	3×10^{-8}	5×10^{-10}	3×10^{-7}	3×10^{-8}	10^{-10}	10^{-7}	10^{-7}
APIEZON 'C'	0.002	0.35	5×10^{-7}	5×10^{-8}	3×10^{-8}	3×10^{-7}	3×10^{-8}	2×10^{-9}	10^{-7}	10^{-7}
MERCURY — EM2 only	—	0.7	10^{-3}	10^{-3}	—	10^{-3}	10^{-7}	2×10^{-8}* (See Notes)	10^{-7}	10^{-7}
AIR SPEED: l/s	150		80	65		50	30		35	25
HYDROGEN SPEED: l/s	200		150	140		115	85		90	75







E02 AND EM2 VAPOR DIFFUSION PUMP-WATER COOLED



E02 AND EM2 VAPOR DIFFUSION PUMP-AIR COOLED

Figure 11. Diffusion Pump (Edwards) With Performance Data (Sheet 2 of 2)

STOKES

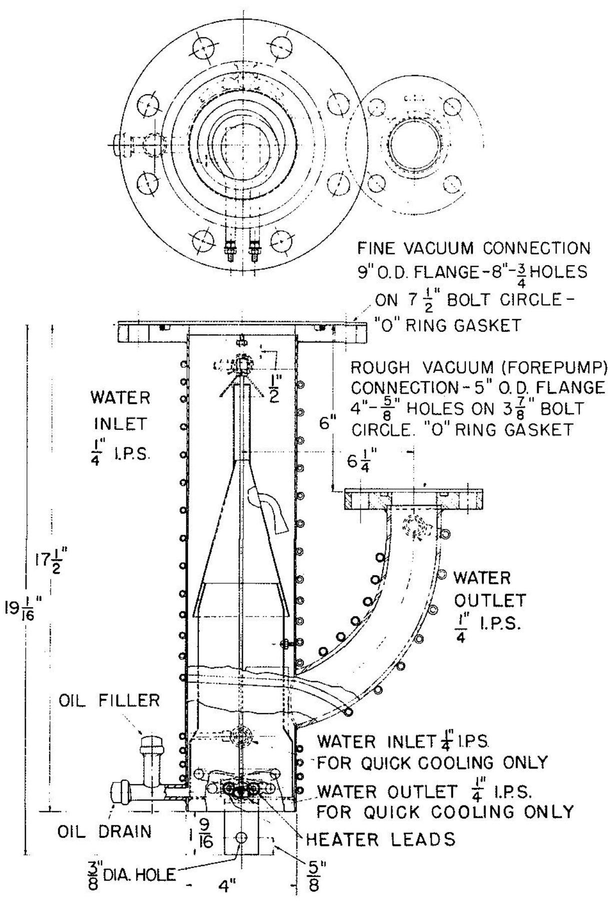
HIGH VACUUM COMPONENTS

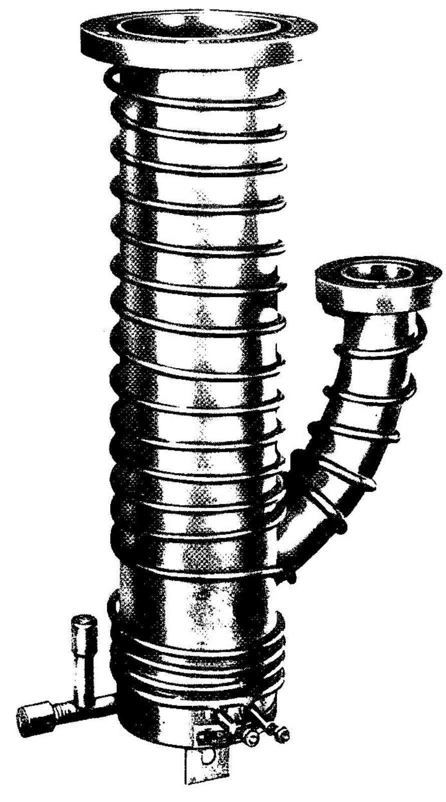
RING-JET DIFFUSION PUMP SERIES 160—4-INCH SIZE

This pump is designed for use with small vacuum heat-treating furnaces, dollies for aluminizing TV tubes and laboratory vacuum metallizers. Forepressure tolerance is high.

Maximum pumping speeds are attained in the range of .1 to 5 microns when using the proper grade Stokes® Molvac "A" fluid. These pumps can be operated with other fluids to attain lower ultimate pressures and higher peak speeds in the pressure range of 1 micron or less. See curve on back of this sheet.

Similar information is available on other Series 160 Ring-Jet Diffusion Pumps of 6-, 10-, and 16-inch sizes and all Series 150 Ring-Jet Booster Pumps of 4-, 6-, 10-, and 16-inch sizes.



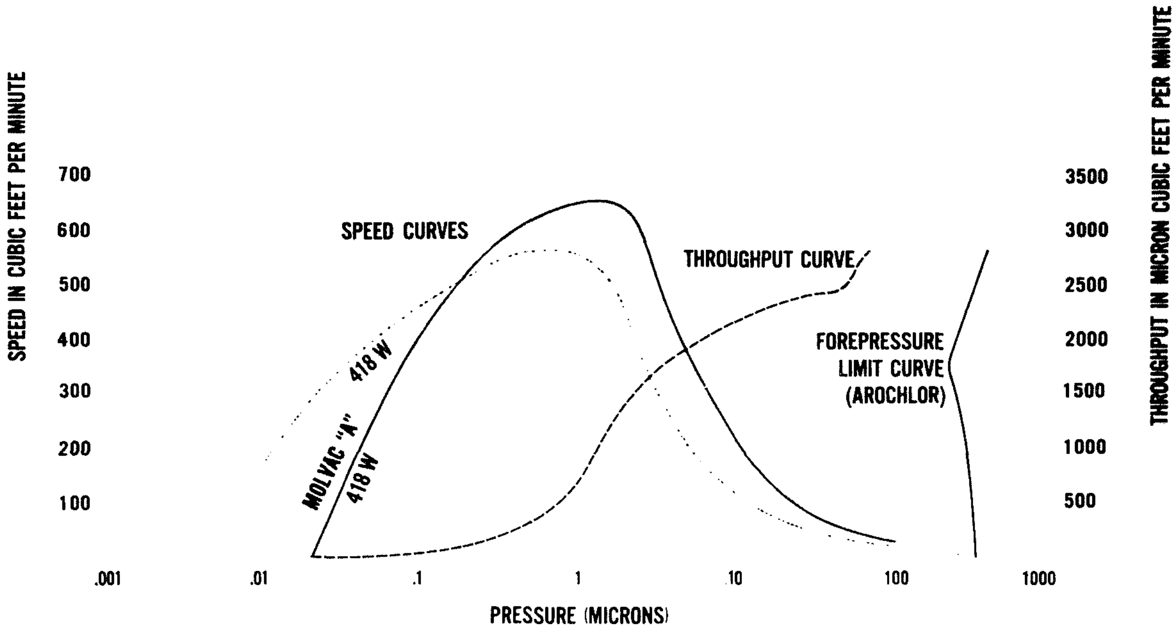


Elevations of Stokes Series 160, 4-inch Ring-Jet Diffusion Pump.

EQUIPMENT DIVISION • PENNSALT CHEMICALS CORPORATION

Figure 12. Diffusion Pump (Stokes) With Performance Data (Sheet 1 of 2)

OPERATING CHARACTERISTICS OF 4" DIFFUSION PUMP WITH 15 CFM FOREPUMP



SPECIFICATIONS

4-inch Stokes Series 160 RING-JET Diffusion Pump

Maximum Pumping Speed	655 cfm
Ultimate Vacuum (Blank-Off).	.022 microns
Recommended Pump Fluid........	Stokes Molvac "A"
Pump Fluid Capacity	200 cc
Heat Input (Rated)	500 watts
Heater Voltage	230 Volts only
Water Cooling Rate at 20° C.	.25 gpm
Weight (Net)	14 lbs.

Separate cooling coil around boiling chamber.

How to use forepressure limit curve: select operating pressure, for example, 3 microns. At this pressure, pump has a throughput of 1650 micron cubic feet per minute. At this throughput, the forepressure limit curve indicates a tolerance of 225 microns.

Performance curves will be sent on request for the 6-, 10-, and 16-inch sizes of Series 160 Diffusion Pumps, and the 4-, 6-, 10-, and 16-inch sizes of Series 150 Booster Pumps.

STOKES VACUUM COMPONENTS DEPARTMENT
PENNSALT CHEMICALS CORPORATION
5500 Tabor Road, Philadelphia, Pa. 19120
215 - 289 - 0100

PENNSALT

467-5M-1P PRINTED IN U.S.A.

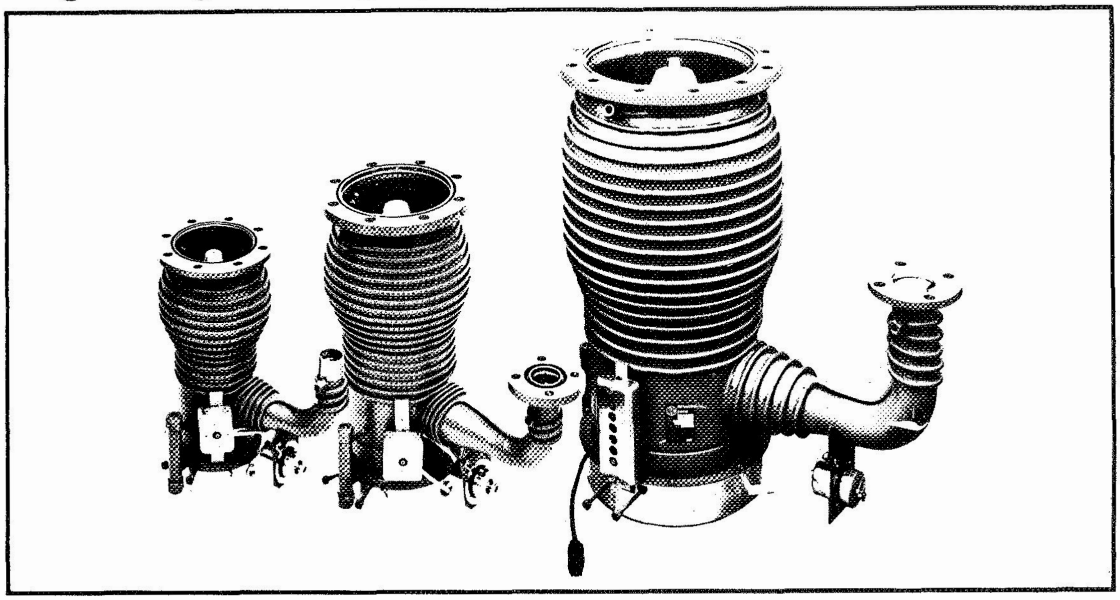
Figure 12. Diffusion Pump (Stokes) With Performance Data (Sheet 2 of 2)

VERY HIGH SPEED DIFFUSION PUMPS
VHS-4, VHS-6, VHS-10

NORTON COMPANY VACUUM EQUIPMENT DIVISION

NRC™ BRAND products

. . . greatest gas handling capacity



FEATURES

High Speed . . .unique body contour* doubles gas capture capability of the first stage, resulting in higher pumping speed and throughput.

Low Backstreaming . . . a patented conduction-cooled cold cap reduces backstreaming by 98%, with little effect on speed. Cap assembly bolts directly to bracket on cold wall of pump.

Clean Operation . . . fractionating assembly separates light fractions in the boiler, preventing them from reaching the vacuum chamber, reducing back migration of light hydrocarbons, and providing lower ultimate pressures.

High Forepressure Tolerance . . . ejector stage, built into the foreline provides another stage of fractionation plus higher forepressure tolerance enabling use of smaller backing pumps.

Quality Construction . . . the pump body, flanges, and boiler are stainless steel to provide corrosion-free construction and minimum outgassing. Cooling coils are machine-wrapped and furnace-brazed to the pump body for positive attachment and neat appearance. They are oval-shaped in cross-section for maximum cooling contact. Dimensions of orifices in the jet assembly are precisely controlled to assure exact vapor distribution.

Automatic Protection . . .a protective thermostat** between the last water cooling coil and the boiler — two relatively fixed temperature points — can automatically switch the heater off if there is an abnormal rise in temperature. This protects against operation at low oil levels, water failure, and inadvertent operation without roughing pump. A foreline baffle minimizes oil loss even if the pump is incorrectly air-released.

Quick, Efficient Heating . . . fast response, inexpensive to replace, heater reduces thermal lag. Oil is vaporized in less than 10 minutes for fast pump starting. Finned boiler plates increase heat transfer area by 100% and keep oil temperature at about 220°C, minimizing production of light oil fractions which are difficult to trap.

GENERAL DESCRIPTION

NRC VHS series pumps set a new standard for diffusion pump performance. Their unique body contour design doubles gas capture volume, thereby doubling throughput at any given pressure. They are the world's fastest diffusion pumps — providing 30% higher pumping speed than any like sized units on the market today.

All three VHS diffusion pumps are capable of attaining ultimate untrapped pressures in the extreme high vacuum range and provide constant pumping speed below 1 x 10^{-3} torr. These high performance pumps are characterized by an exceedingly low backstreaming rate. A patented cold cap† and a fractionating jet assemby assure clean operation. High forepressure tolerances permit the use of small backing pumps in low pressure applications.

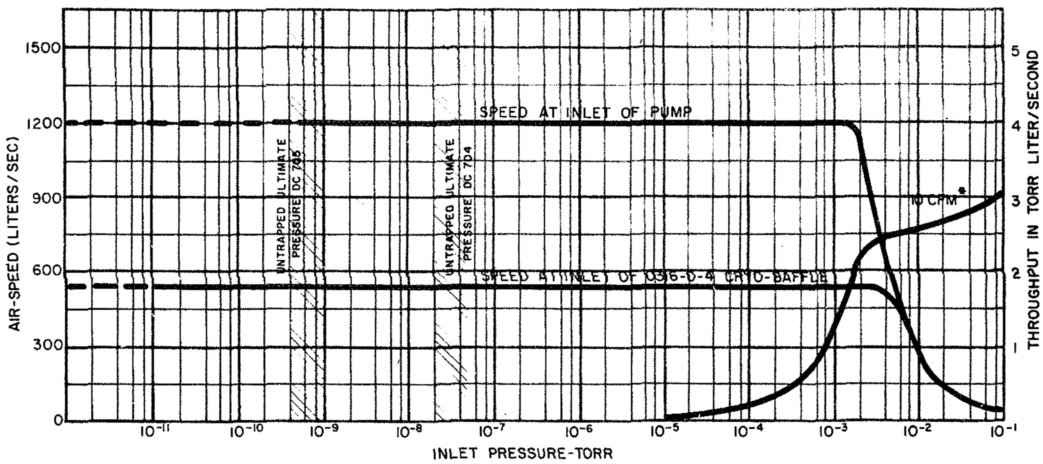
*U.S. Patent 3363830 **U.S. Patent 3282330

†Licensed to Norton Company exclusively from Edwards High Vacuum. Ltd. U.S. Patent 2919061

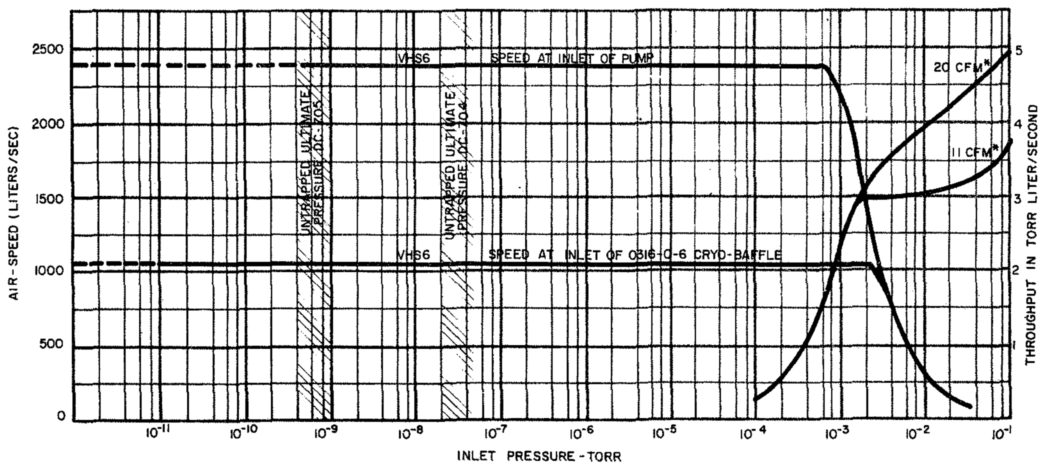
Figure 13. Diffusion Pump (NRC) With Performance Data (Sheet 1 of 2)

SPEED CURVES

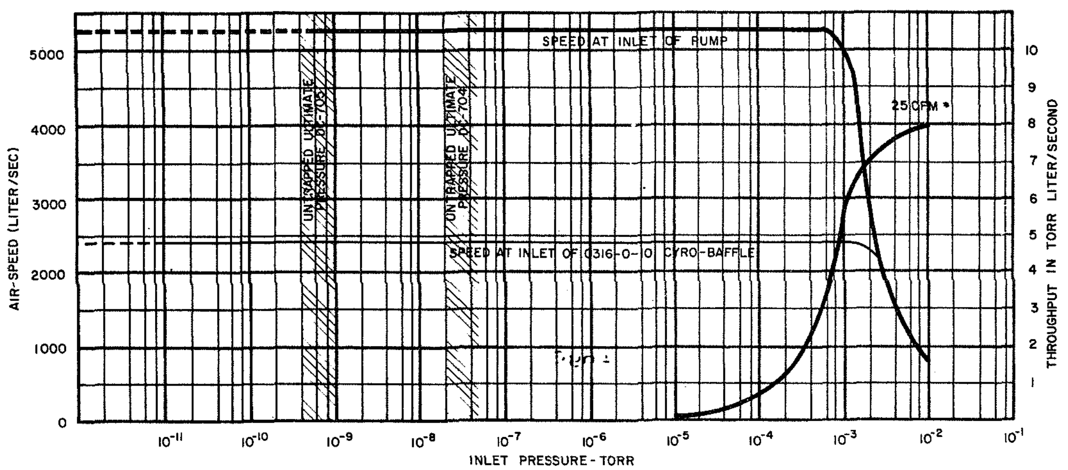
NRC VHS 4



NRC VHS 6

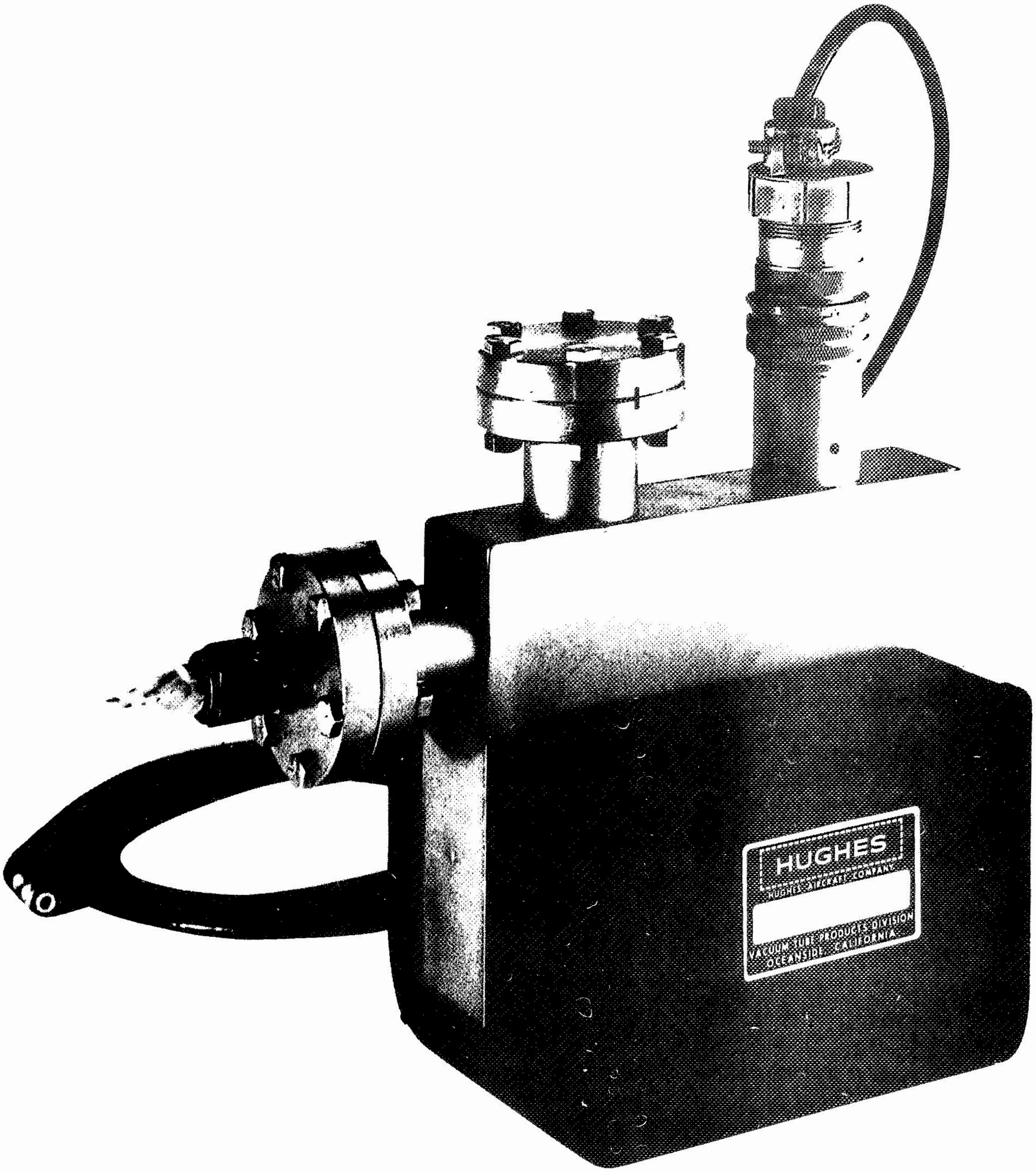


NRC VHS 10



***Actual speed at diffusion pump foreline flange.**
Speed curves based on standard AVS test procedures.

Figure 13. Diffusion Pump (NRC) With Performance Data (Sheet 2 of 2)



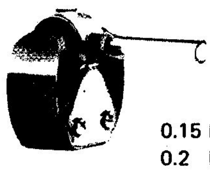
20 LITER PER SECOND ION PUMP
HUGHES MODEL VP-20

Figure 14. Ion Pump (Hughes)

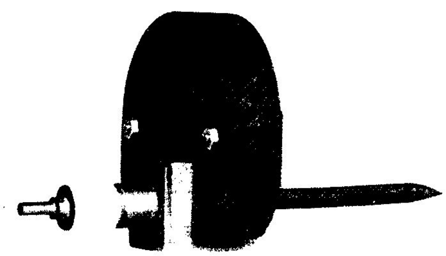
Westinghouse

Ion Sorption Pumps

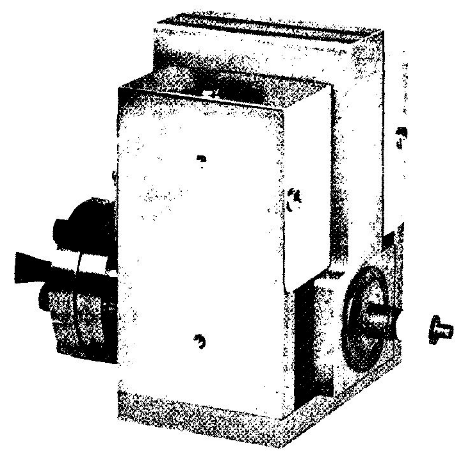
Ceramic-Metal Construction
Range 10^{-4} Torr to 10^{-9} Torr



0.15 Liter/Second
0.2 Liter/Second



1 Liter/Second



8 Liters/Second

Westinghouse Ion Sorption Pumps are available with pumping speeds of 0.15 liter/second, 0.2 liter/second, 1 liter/second, and 8 liters/second for dry air. These pumps are the same rugged, high quality designs that have been used on Westinghouse electronic tubes for the past seven years. They represent seven years of pump manufacturing and application experience.

The Westinghouse vacuum research program, well known for the development of the Bayard-Alpert and Schulz-Phelps ionization vacuum gauges, is continuing to explore new processes to solve your pumping problems.

September 1968
Supersedes TD 86-437 dated March 1968
S6–2D–11C, S5–11B, WI–800

Figure 15. Ion Pump (Westinghouse)

The Ideal Pump for High-Power Electron Tubes

- *Established Reliability . . . In Use Over Seven Years*
- *Gauge and Leak Detector Functions . . . Immediately Reads Pressure and Helps You Pinpoint Leaks in Any Vacuum Envelope*
- *Easy Operation . . . A Simple Switch Turns the Pump On*

VacIon® APPENDAGE PUMPS
0.15, 0.2, and 1 L/S

Data Sheet

APPLICATIONS

These Appendage Pumps are used to obtain, measure and maintain ultra-high vacuum under low gas loads. They are intended specifically for use on sealed vacuum devices such as electron tubes and cryogenic dewars. Small, light-weight and extremely rugged, these pumps are excellent for applications where severe environmental conditions are encountered.

OPERATION

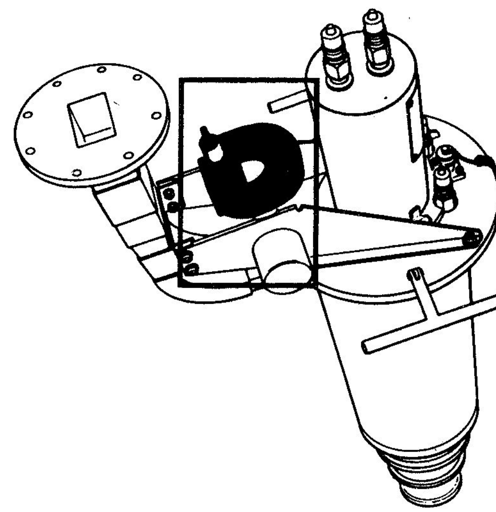
The Appendage Pumps are small units based on the renowned Varian VacIon Pump design. The complete pumping system includes the pump, its Alnico magnet, and power supply. These diode-type pumps operate on the principle of ion-gettering in the pressure range from 10^{-2} Torr to less than 10^{-9} Torr. A roughing pump is needed to lower the system pressure from atmosphere to between 10^{-2} and 10^{-4} Torr.

ADVANTAGES

Proved Reliability. VacIon Appendage Pumps have been preferred over other designs by many satisfied customers for more than seven years. Electron Tube manufacturers select these pumps to create and hold the vacuum in their most valuable tubes. Military and government specfications often require the use of VacIon Appendage Pumps for vacuum holding and measurement in high-power microwave tubes.

Serves as Pressure Gauge. The pump current is directly proportional to the pressure in the vacuum system. Therefore, you determine pressure simply by measuring the current drawn by the pump with the control unit meter or a graphic recorder.

Acts As Leak Detector. The pump current will change when a tracer gas displaces the air entering a system. This change is shown on the control unit meter or recorder, enabling you to detect leaks easily. For high-sensitivity leak detection, the VacIon Pump Leak Detector can be used. This connects to any VacIon Pump and amplifies and displays the change in pump current. (A high-voltage adapter must be used to connect the 0.15 and 0.2 l/s pumps.) The leak detector can locate leaks as small as 2.6×10^{-11} std. cc/second in systems operating at pressures below 10^{-8} Torr. Because the leak is checked through the VacIon Pump, it is unnecessary to open the system to atmosphere. Leaks in vacuum tubes and similar devices can be found during processing, testing, or actual operation.



Holds High Vacuum Even With Power Failure. A VacIon Pump is completely sealed from the atmosphere. A power failure stops the pump without admitting air or contaminants to the vacuum system.

Bakeable for Ultra-High Vacuum Base Pressure. These pumps can be operated at 450°C, since the magnets are bakeable to this temperature. Without magnets, the pumps can be baked to 550°C; the heliarc welding and copper-gold brazing on the pump body readily withstand this temperature.

Easy to Install and Operate. The pumps can be mounted in any position. The magnet on each pump is supported by a bracket welded to the pump body. This gives the entire pump/magnet assembly the ability to withstand severe shock and vibration. After rough-pumping to below 10^{-2} Torr, one switch turns the VacIon Pump on.

Operates Down to 1×10^{-9} Torr. The pumps will operate from 10^{-2} to 10^{-9} Torr. In appendage applications, they are normally operated at pressures below 10^{-5} Torr.

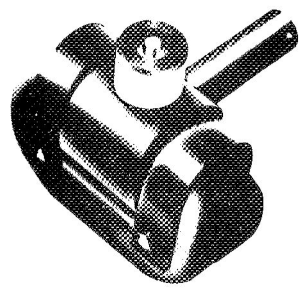
Uses Variety of Connecting Tubulations. Various types of connecting tubulations are available, as shown below. Others can be provided to meet special needs.

varian
vacuum division
611 hansen way/palo alto, california 94303

European inquiries:
VARIAN A.G.,
Baarerstrasse 77, Zug, Switzerland

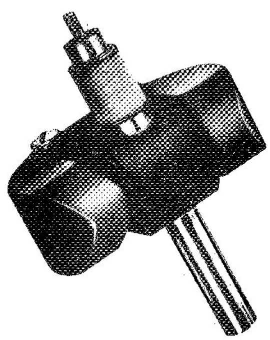
Figure 16. Ion Pump With Specifications (Varian) (Sheet 1 of 2)

PUMP SPECIFICATIONS AND DIMENSIONS



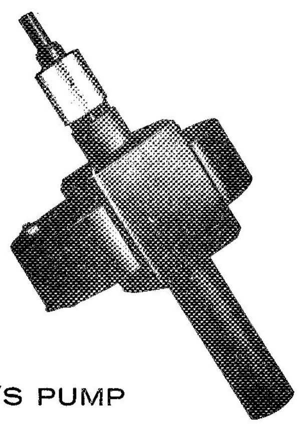
0.15 L/S PUMP

MODEL NO.	DESCRIPTION	WEIGHT (Lb.)	WEIGHT (Kg.)	TUBE MATERIAL	DIMENSIONS A O.D.	DIMENSIONS B WALL	DIMENSIONS C —
913-0018	Pump with Copper Tubulation	0.13	0.06	Copper	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{32}$" (0.8 mm)	$1\frac{11}{16}$" (43.0 mm)
913-0019	Pump with Stainless Steel Tubulation	0.13	0.06	Stainless Steel (Type 304)	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{32}$" (0.8 mm)	$1\frac{11}{16}$" (43.0 mm)
913-0024	Pump with Type 7052 Glass Tubulation	0.13	0.06	7052 Glass	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{16}$" (1.6 mm)	$3\frac{5}{8}$"(2) (92.2 mm)
913-0021	Permanent Magnet	0.29	0.13				



0.2 L/S PUMP

MODEL NO.	DESCRIPTION	WEIGHT (Lb.)	WEIGHT (Kg.)	TUBE MATERIAL	DIMENSIONS A O.D.	DIMENSIONS B WALL	DIMENSIONS C —
913-0002	Pump with Copper Tubulation	0.18	0.08	Copper	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{32}$" (0.8 mm)	$4\frac{1}{4}$" (108.0 mm)
913-0005	Pump with Stainless Steel Tubulation	0.18	0.08	Stainless Steel (Type 304)(1)	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{32}$" (0.8 mm)	$4\frac{1}{4}$" (108.0 mm)
913-0025	Pump with Type 7052 Glass Tubulation	0.18	0.08	7052 Glass	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{16}$" (1.6 mm)	$6\frac{5}{16}$"(2) (161.4 mm)
913-0003	Permanent Magnet	0.65	0.30				



1 L/S PUMP

MODEL NO.	DESCRIPTION	WEIGHT (Lb.)	WEIGHT (Kg.)	TUBE MATERIAL	DIMENSIONS A O.D.	DIMENSIONS B WALL	DIMENSIONS C —
913-0007	Pump with Copper Tubulation	0.65	0.30	Copper	$\frac{3}{8}$" (9.6 mm)	$\frac{1}{32}$" (0.8 mm)	$7\frac{1}{2}$"(3) (190.5 mm)
913-0008	Pump with Stainless Steel Tubulation	0.65	0.30	Stainless Steel (Type 304)	$\frac{3}{4}$" (19.1 mm)	$\frac{3}{64}$" (1.2 mm)	$6\frac{9}{16}$" (166.8 mm)
913-0009	Pump with Pyrex Tubulation	0.65	0.30	Pyrex	$\frac{3}{4}$" (19.1 mm)	$\frac{1}{16}$" (1.6 mm) (approx.)	$9\frac{5}{16}$"(4) (308.6 mm)
913-0010	Pump with Type 7052 Glass Tubulation	0.65	0.30	7052 Glass	$\frac{3}{4}$" (19.1 mm)	$\frac{1}{16}$" (1.6 mm) (approx.)	$9\frac{5}{16}$"(4) (308.6 mm)
913-0011	Permanent Magnet	2.0	0.91				

NOTES:

(1) Stainless Steel Tubing is nickel-plated except for the last ⅛ inch of length.

(2) 7052 Glass Tubes extend 2 inches beyond the end of the metal tubing. (Dimension indicated is to the end of the glass.)

(3) Minimum useable length. Pump is shipped under vacuum with copper tubes pinched off.

(4) Pyrex and 7052 Glass Tubes extend 4½ inches beyond the end of the metal tubing. The Pyrex tubulated pump has a graded seal between the Kovar sealing glass and the Pyrex. (Dimension indicated is to the end of the glass.)

All dimensions are in inches (and millimeters).

Figure 16. Ion Pump With Specifications (Varian) (Sheet 2 of 2)

TITANIUM SUBLIMATION PUMPS AND CONTROLS

Models 22TP212 and 22TP310

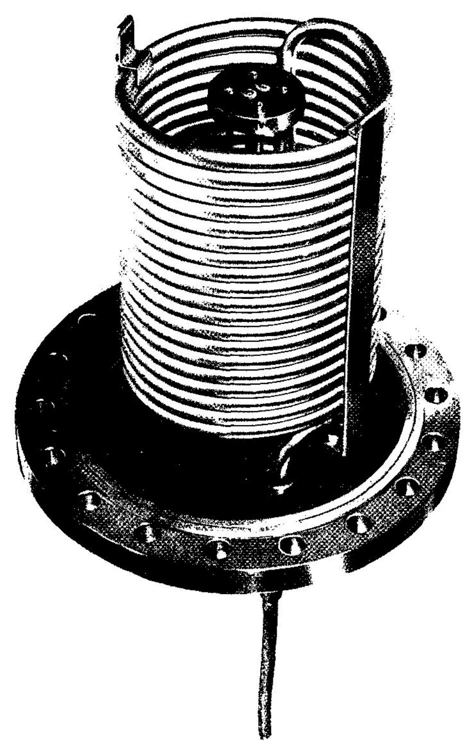
The mechanism of titanium sublimation pumping is the formation of stable compounds between sublimed titanium and active gases (gettering). Typically, compounds formed with nitrogen and oxygen are stable well above a temperature of 1000 C.

The pumping action of the unit is a function of the area plus the temperature of the condensing surface, evaporation rate of the filament and pressure.

The time for saturation of the titanium surface is a function of pressure and, thus, various duty cycles are recommended for different pressure ranges to assure efficient and effective pumping. The newly designed filaments provide a highly efficient evaporation of titanium with a minimum of outgassing.

General Electric's titanium sublimation pumps are available in two standard sizes and can be used with 25, 100, 250, 500, and 1200 liter/second ion pumps to provide pulse pumping for intermittent high outgassing rates and for lower ultimate pressures (10^{-11} and lower). The unique design, incorporating a copper tubing condensing surface, enables the unit to be water or liquid-nitrogen cooled for lower ultimate pressures in shorter times. In the smaller pumps (25, 100, and 250 liters/second), the unit is mounted in a "tee" to the ion-pump flange. Pumping speeds of systems can be increased by 550 liters/second with the G-E Model 22TP212 and by 5000 liters/second with G-E Model 22TP310.

Four titanium filaments are mounted on the sublimation cartridge by means of set screws. Each filament has a life of 6-8 hours under constant evaporation at 35-42 amps. When pressures reach 10^{-10} torr and lower, filament life will



Titanium sublimation pump – 550 liter/second unit

GENERAL ELECTRIC

Figure 17. Sublimation Pump With Specifications (General Electric) (Sheet 1 of 2)

be longer since continuous operation is not required. Operation of the unit a few times a day will maintain pressure unless excessive outgassing is taking place.

The cartridge is mounted on a 2 3/4-in. OD flange; a mating flange is attached to the flange holding the coil assembly. The cartridge can be removed and the coil assembly still be used for cryogenic pumping. On the larger-size unit, the assembly can be mounted through the bottom of the ion pumps (500 and 1200 liters/second).

FEATURES

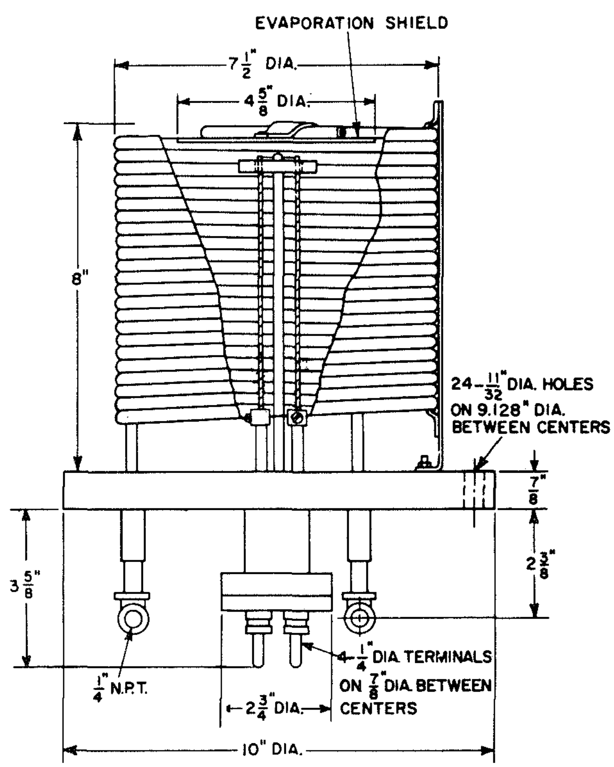
- Two ratings available with pumping speeds of 550 and 5000 liters per second.
- Four replaceable and interchangeable long-life filaments on each model. Gives up to 8 hours continuous duty per filament.
- Evaporation rate and duty cycle are adjustable to accommodate varying gas loads.
- Copper tubing condensing surface can be water or liquid-nitrogen cooled.
- Effective over pressure range from 100 microns through the ultra-high-vacuum region.
- Capable of flange mounting to ion pump, "tee" or vacuum system.
- High pumping capacity to handle peak gas loads and rapid pumpdown to low pressures.

ACCESSORIES

Titanium Sublimation Pump Control Model 22TC221 (Rack Mount)

General Description

The Model 22TC221 Control may be used with both the 22TP212 and 22TP310 Titanium Sublimation Pumps. It provides a choice of manual or adjustable automatic duty cycle and switching to any of the four filaments. Filament power is manually adjustable to 50 amps a-c.



Titanium sublimation pump dimensions - Model 22TP310 (5000 l/s) showing filament assembly

Figure 17. Sublimation Pump With Specifications (General Electric) (Sheet 2 of 2)

CRYOSORPTION PUMP
NRC 220

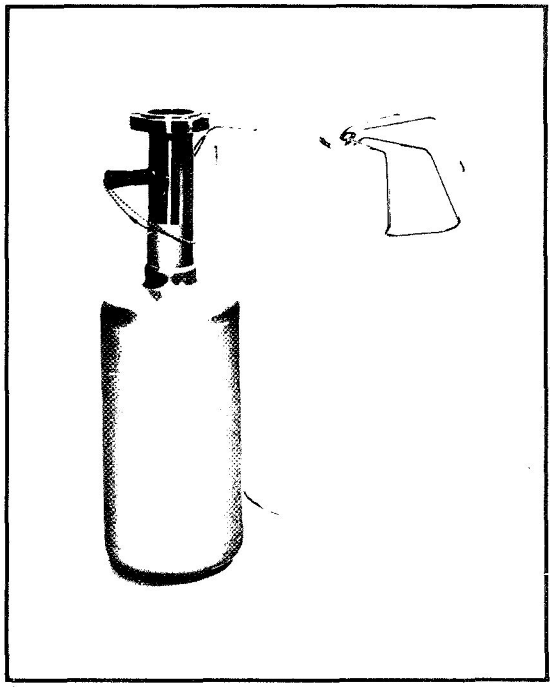
NRC™ BRAND products

NORTON COMPANY VACUUM EQUIPMENT DIVISION

. . . faster cycling . . . economical . . . high speed

GENERAL DESCRIPTION

NRC 220 cryosorption pump is designed to evacuate high vacuum systems to pressures below 1 x 10^{-3} torr. It can be used wherever a clean, contamination free system is desired, such as in thin film deposition, analytical instruments, particle accelerators, electron tube manufacturing, sputtering systems, vacuum furnaces, ultrahigh vacuum material studies, and components testing.



PRINCIPLES OF OPERATION

Molecular sieve materials have the ability to sorb gases when cooled and release gas molecules when heated. The NRC 220 cryosorption pump effectively cools the molecular sieve contained within its extruded aluminum body to liquid nitrogen temperatures, sorbing gases and reducing the pressure in the vacuum chamber.

As a general rule, one NRC 220 pump is required for every 50 liters volume. Use of more than one unit increases a system's ability to trap the low boiling point gases (helium, hydrogen, and neon). These are difficult to trap and limit the ultimate pressure a single stage sorption pumping system can attain. On larger systems over 200 liters, three or more stages of sorption pumping may be required. Information on multi-stage sorption pumping is available upon request.

FEATURES

Faster Cool-down and Shorter Cycling . . . Because of its extruded aluminum, internally finned body, the NRC 220 cools to cryogenic temperatures from room temperature in less than eight minutes and is ready to begin pumping approximately 50 percent sooner than a stainless steel pump. Also, by the use of an optional bakeout mantle, the pump can be heated to 250°C in about the same time when regeneration is required. Design of the unique, one-piece envelope/fin extrusion assures optimum heat transfer between molecular sieve and the liquid nitrogen for clean, fast pumping of high vacuum systems.

Economical Use of Liquid Nitrogen . . Even when more than 40 percent of the liquid nitrogen has evaporated, the NRC 220 operates effectively, because of its high heat transfer characteristics. Suspended from three stainless steel hangers, the specially molded dewar allows easy filling from any angle.

Compatibility With All Stainless Steel Systems . . A brazed joint attaches the aluminum body to a stainless steel neck, which terminates in a 1½" I.D., 2¾" O.D. Conflat® flange or NRC foil flange.

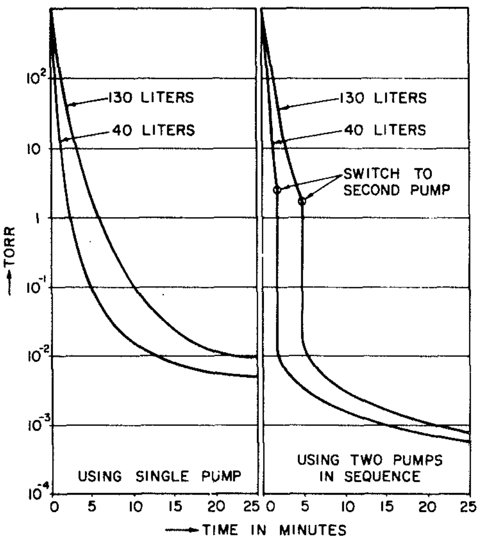
High Speed Argon Pumping . . . Against continuous argon gas loads of up to 0.08 atm cc/sec, one NRC 220 unit can maintain pressure of 10^{-2} torr for 500 hours. At double this pressure, the unit can operate for 200 hours against a gas load of 0.18 atm cc/sec.

Optional Bakeout Mantle . . . On a small system, the NRC 220 may be used several times without regeneration, but as molecular sieve used for sorption approaches saturation, performance of the pump is less efficient.

To regenerate the molecular sieve material, an optional bakeout mantle is available to bake the pump at 250°C to drive off water vapor and other gases sorbed by the molecular sieve material. The mantle laces around the pump body and is thermostatically controlled to prevent overheating.

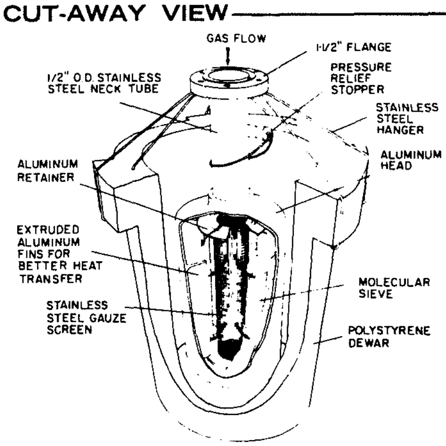
Figure 18. Sorption Pump With Specifications (NRC) (Sheet 1 of 2)

PUMPDOWN CURVES



Comparison of pumpdown on two different volumes of 40 and 130 liters using a single cryosorption pump and using two cryosorption pumps in sequence.

CUT-AWAY VIEW



SPECIFICATIONS

Dimensions

NRC 220 Overall height .... 14.9"
Pump body O.D. .... 4.5"
Polystyrene dewar (NRC 0281-F2182-301) Included with pump .... 10" O.D. x 13" long

Space required for removal of dewar .... 10"

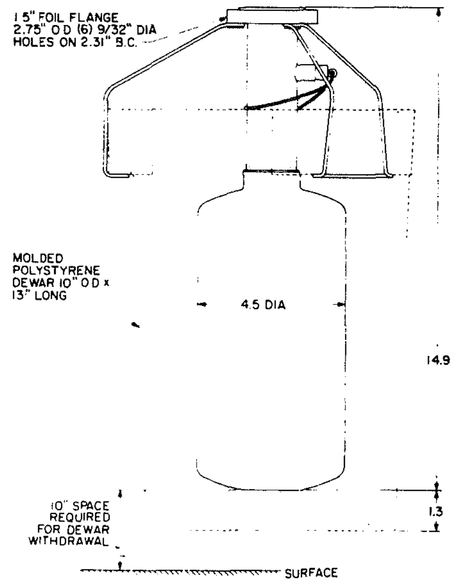
Total dewar capacity .... 5.7 liters

Liquid nitrogen required to fill dewar with NRC 220 in position .... 3.25 liters

Charge (NRC 0281-F4155-301) Included with pump
Molecular sieve material .... 5Å pore size
Amount per charge .... 2¼ lbs.

Power requirements for optional bakeout mantle (NRC 0291-F2699-301) .... 115V, 1 phase, 50/60 Hz, 600 W

OUTLINE DIMENSIONS



Norton Company reserves the right to change design and specifications without notice.

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Atlanta, Georgia 30328	Columbus, Ohio 43212	Willowdale, Ontario	London, England
Chicago, Illinois 60645	Willow Grove, Pennsylvania 19090	Ottawa, Ontario	Munich, Germany
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MANUFACTURING PLANTS IN: Newton, Massachusetts; Palo Alto, California; Columbus, Ohio and Saint-Julien, France.

NORTON VACUUM EQUIPMENT DIVISION
FORMERLY NRC EQUIPMENT CORP.
160 CHARLEMONT ST. NEWTON, MASS. 02161

PRINTED IN U.S.A.

Figure 18. Sorption Pump With Specifications (NRC) (Sheet 2 of 2)

Vacuum Products
SYSTEMS • COMPONENTS • INSTRUMENTS
VACUUM PRODUCTS BUSINESS SECTION
SCHENECTADY, N. Y. 12305

NEW DESIGN SORPTION PUMP

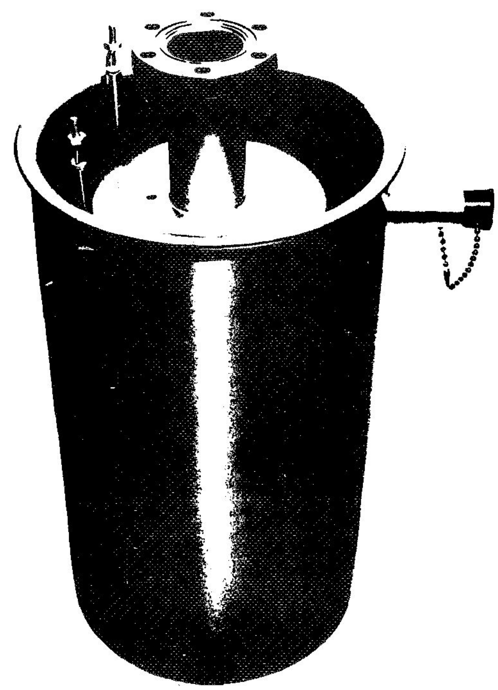
General

The General Electric Molecular Sieve Sorption Pump is designed primarily to provide ultra-clean rough pumping of vacuum systems to 10 microns or lower. Secondly, because of its unique features, it can be used to attain pressures in the high-vacuum region when used as a trap/pump in conjunction with a mechanical pump or diffusion pump connected to its exhaust port.

The liquid-nitrogen Dewar and bakeout coil as integral parts of the sorption pump are an exclusive G-E feature. The pump is constructed (see cross-section) so that molecular sieve material is contained in a cylindrical chamber and an annular chamber, which are concentric with each other and connected to a common pump port. The construction is such that liquid nitrogen completely surrounds the cylindrical chamber and the inner and outer walls of the annular chamber. This configuration, in conjunction with internal heat-transfer fins, permits faster chilling of the sieve material and also maintains it at a more uniform temperature for greater efficiency and faster pumpdown.

Features

- Fast cooling and pumpdown
- Integral liquid nitrogen Dewar
- Integral bakeout heater



Model 22HP111 Molecular Sieve Sorption Pump

- Liquid nitrogen can be added while hot
- Useful as a trap as well as a pump
- Available with or without flanges on ports
- Flanges are new compatible design

GENERAL ELECTRIC

Figure 19. Sorption Pump With Specifications (General Electric) (Sheet 1 of 2)

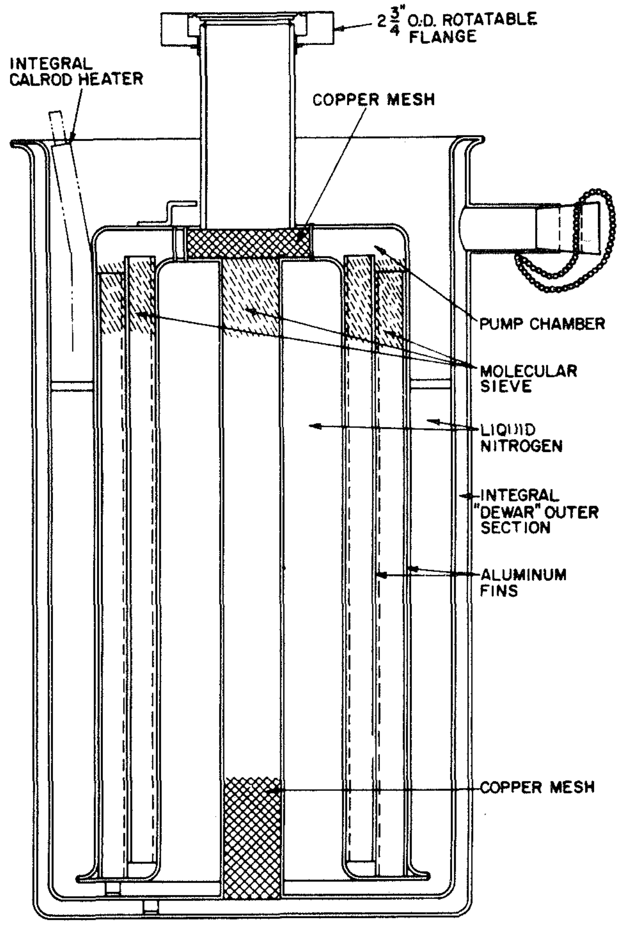
Description

The Sorption Pump is offered in three models, each differing only by the means of connection to the vacuum system or the configuration of the side (exhaust) port. Each model has as integral parts of the pump, a liquid-nitrogen Dewar and Calrod* bakeout coil.

The molecular sieve sorption material, Linde 5A, is the pumping medium of the sorption pump. The pumping action is achieved by the sorption of gas molecules by the molecular sieve material when it is chilled by liquid nitrogen. After a pumpdown cycle, the sorption pump is reactivated by merely energizing the heater. The liquid nitrogen quickly boils off and the molecular sieve is heated to 250 C for a few hours. This allows the gases and water vapor that have been previously sorbed to escape through the exhaust port.

A salient feature of the G-E Sorption Pump is that liquid nitrogen can be added while the pump is at bakeout temperature. This reduces cooldown time very significantly, thereby reducing the total roughing cycle. Since the pump, heater, and liquid-nitrogen sump are all designed into one integral unit, it is not necessary to remove a bakeout jacket and add a liquid-nitrogen container before using the pump after reactivation.

A unique feature of the G-E pump is that it can be used as a trap, in addition to being a pump, in conjunction with other pumping means. It can be seen



Cross-section of Molecular Sieve Sorption Pump

from the cross-section drawing that if a mechanical pump were connected to the side port the molecular sieve in the inner cylinder of the sorption pump would prevent any oil migration into the vacuum system. This feature is useful in attaining pressures in the high-vacuum region, or for exhaust applications where unusually high gas loads are encountered during part of the cycle. This feature also provides for more effectual nitrogen flushing of the sorption pump and vacuum system. Recent studies have shown that nitrogen flushing results in faster pumpdown and lower ultimate pressures.

* Trade-mark of General Electric Co.

Figure 19. Sorption Pump With Specifications (General Electric) (Sheet 2 of 2)

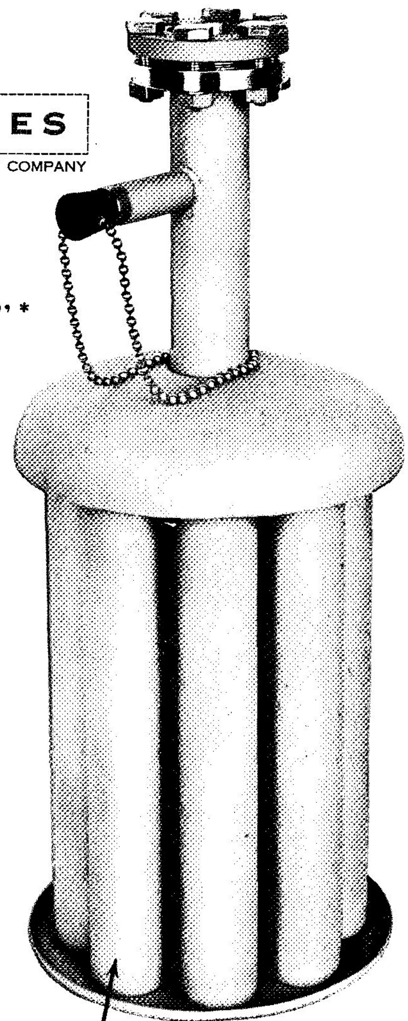
HUGHES

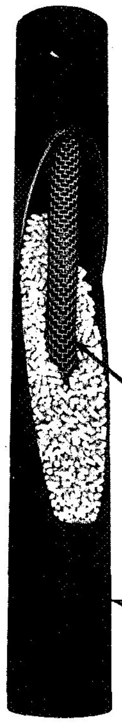
HUGHES AIRCRAFT COMPANY

THE

"GULPER"*

PATENTS APPLIED FOR





FEATURES ACCELERATED SORPTION THE PRODUCT OF THE:

9 CYLINDER DESIGN

THE GAS EXPOSURE INSERTS WHICH MAXIMIZE THE EXPOSURE OF THE GAS TO CHILLING

THE OPTIMUM SURFACE TO VOLUME RATIO OF THE CYLINDER

*Trademark of Hughes Aircraft Company

VTP MODEL SP-9

THE "GULPER"*

SORB PUMP

Hughes has taken the principle of sorption pumping and given it new values in The "Gulper," the first sorb pump to offer higher volumetric pumping capacity with less refrigerant. Improved design includes doubling the surface area to be chilled and increasing the exposure of the gas to the chilled surface.

ADVANTAGES OVER CONVENTIONAL SORPTION PUMPS:

1

Requires less zeolite (molecular sieve) which occupies only the annular space surrounding the exposure inserts.

2

Uses less liquid nitrogen because it becomes temperature stabilized in 5 minutes. Stabilizes at ambient temperature in about one-fourth the time of other sorb pumps.

3

Pumps down faster since the gas exposure inserts increase gas flow to the chilled zeolite.

4

Chills down faster because the surface area of the GULPER'S 9-cylinders is twice that of the conventional mono-cylinder design.

5

Responds rapidly to accelerated heating by tape, directed flame or furnace.

6

Exposure inserts are permanent, require no maintenance.

7

Replacing the zeolite is simple: Invert the pump to discharge the old then set upright to add the new zeolite.

CREATING A NEW WORLD WITH ELECTRONICS

HUGHES

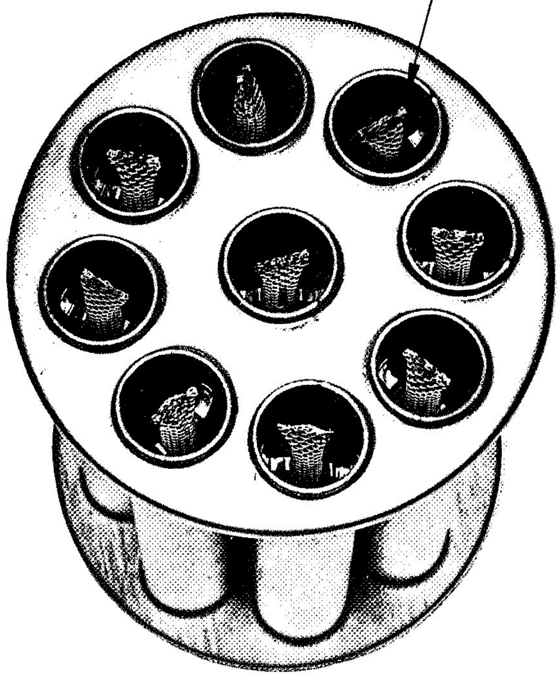
HUGHES AIRCRAFT COMPANY
VACUUM TUBE PRODUCTS DIVISION
OCEANSIDE, CALIFORNIA

Figure 20. Sorption Pump With Specifications (Hughes) (Sheet 1 of 2)

The effectiveness of a sorb pump depends upon its ability to adsorb gases on the chilled molecular sieve in the shortest time. By raising that ability to new levels, the Hughes "GULPER" has broadened the usefulness of sorb pumping to include service previously reserved for the mechanical forepump.

Although it has an internal volume of only 1 liter, the GULPER will pump 25,000 torr liters (33 atmospheric liters) in 15 minutes.

Together with a thermocouple gauge and control, it provides trouble-free, uncontaminated vacuum pumping and measurement for minimum expense.



SPECIFICATIONS

WEIGHT .... 5.5 lbs
HEIGHT TO FLANGE .... 12⅛ inches
DIAMETER .... 5 inches
LENGTH OVERALL .... 8½ inches maximum
MOUNTING .... Vertical
REFRIGERATION .... Liquid Nitrogen
CONTAINER .... STD. 1-gal. Dewar
PRESSURE RELIEF .. Simple Plug with chain
RANGE .... To less than 20 microns

STRUCTURE:

Type 304 stainless steel, heliarc welded

CONNECTIONS:

1 inch I.D. Flange with mating flange for attachment to system; copper gasket.

APPLICATIONS

Use the "GULPER" as a fore pump singly or in multiples to evacuate to below 20 microns, that pressure at which ion pumps begin operating. Or use it alone to produce absolutely contamination-free vacuum in laboratory research.

EXAMPLES

1. Bacteriology
2. Metallurgy
3. Gaseous Discharge
4. Calibration
5. Sterilization
6. Micro-Miniaturization
7. Hermetic Sealing
8. Permanent Environment in component packaging
9. Evaporation

COMPANION GAUGE & CONTROL

The Hughes TG-7822 Precision Thermocouple Gauge Tube is ideal for sensing vacuum pressure to 0.1 Micron. It performs best when powered with the TGC-200 Thermocouple Gauge Control.

CREATING A NEW WORLD WITH ELECTRONICS

HUGHES

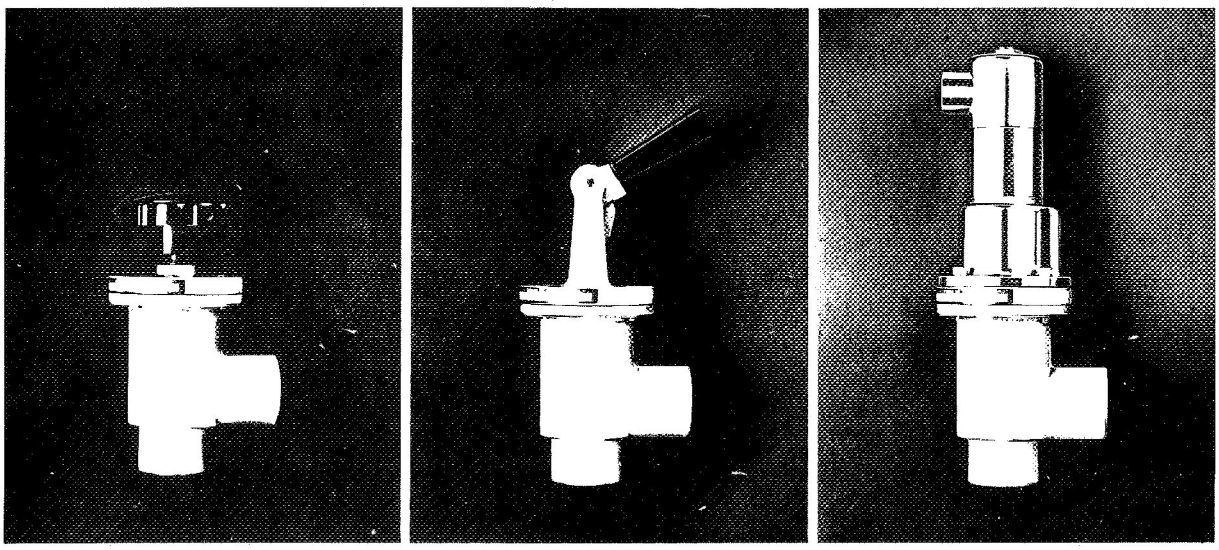
HUGHES AIRCRAFT COMPANY

For additional information, please write:
HUGHES AIRCRAFT COMPANY
VACUUM TUBE PRODUCTS DIVISION
ATTN: VACUUM DEVICES
2020 OCEANSIDE BLVD., OCEANSIDE, CALIFORNIA
TELEPHONE: (714) 722-2101
TWX: 910 322-1380

Figure 20. Sorption Pump With Specifications (Hughes) (Sheet 2 of 2)

TEMESCAL VACUUM VALVES

ANGLE VALVES SERIES 1000



FEATURES

Forged Bodies

Replaceable Bellows

Interchangeable, Manual, Toggle or Pneumatic Actuators

Die Cast Solenoid Heads

Buna N "O" Ring Seals

Standard Pipe or Solder Connections

DESCRIPTION

The valves listed in this data sheet are designed for both laboratory and industrial high vacuum service at pressures to 10^{-7} torr. Capable of being mounted in any position, the valves will seal against 15 PSIG differential pressure in either direction. Since the bellows are "O" Ring sealed to the actuator assemblies, bellows replacement is relatively simple and inexpensive.

Vacuum integrity is assured by the use of forged bodies which eliminate solder or brazed joints, and the internal mechanisms are constructed of wear-resistant metals.

All Temescal vacuum valves are tested on a helium sensitive mass spectrometer vacuum leak detector under the most sensitive test conditions.

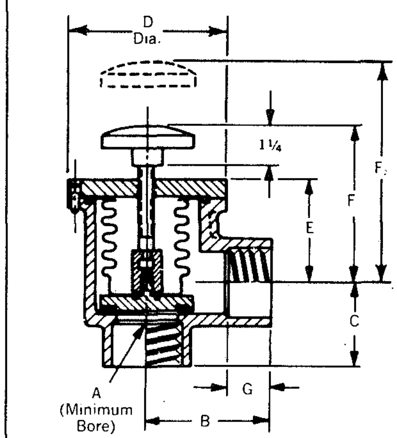
Port connections are standard female pipethread or female solder. Applications include roughing, foreline, leak detection or small process piping.

TEMESCAL, THE WORLD'S LEADING PRODUCER OF HIGH VACUUM VALVES

Figure 21. High Vacuum Valves With Specifications (Temescal) (Sheet 1 of 2)

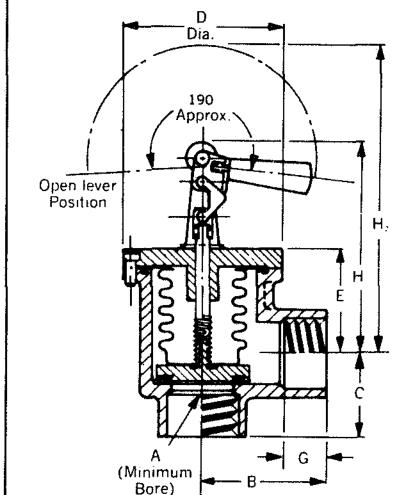
TEMESCAL VACUUM VALVES SPECIFICATIONS

ANGLE VALVES SERIES 1000



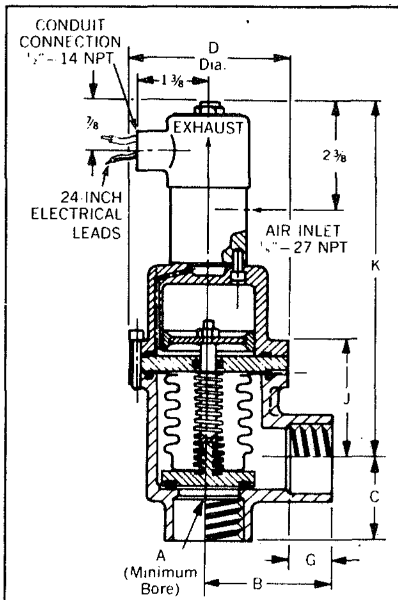
Model 1010—Female Pipe

Model 1110—Female Solder



Model 1020—Female Pipe

Model 1120—Female Solder



Model 1030—Female Pipe

Model 1130—Female Solder

SIZE	DIMENSIONS (inches)												WEIGHT (lbs.) ACTUATION		
	A	B	C	D	E	F_1	F_2	G	H_1	H_2	J	K	Hand	Toggle	Electro Pneumatic
½" / **⅝"**	⅝	1¾	1$\frac{5}{16}$	2¾	1$\frac{11}{16}$	3$\frac{5}{16}$	3¾	⅝	4⅜	6⅞	1$\frac{15}{16}$	6$\frac{11}{16}$	2	2	3¼
¾"	**⅝**	**1¾**	**1$\frac{5}{16}$**	**2¾**	**1$\frac{11}{16}$**	**3$\frac{5}{16}$**	**3¾**	**¾**	**4⅜**	**6⅞**	**1$\frac{15}{16}$**	**6$\frac{11}{16}$**	**2**	**2**	**3¼**
1" / **1⅛"**	1	2$\frac{5}{16}$	1¾	3	2$\frac{9}{16}$	4$\frac{1}{16}$	4$\frac{15}{16}$	⅞	5¼	7¾	2$\frac{13}{16}$	7½	3¾	3½	5¼
1½" / **1⅝"**	1½	2¾	2$\frac{3}{16}$	3⅞	2$\frac{13}{16}$	4¼	5⅜	1	5½	8	3$\frac{1}{16}$	8$\frac{7}{16}$	6¾	6	8½

½, 1, 1½ inch valves have female pipe thread connections; ⅝, ¾, 1⅛, 1⅝ have female solder connections.

ORDERING INFORMATION

All valves should be ordered by size and model number.

1) Pneumatically actuated valves require 60 to 125 PSIG air.

2) Standard versions of pneumatically actuated valves are normally closed with 115 volt 50/60 cps, 10 watt solenoid coils in a NEMA Type 1 enclosure.

3) Normally open pneumatically actuated valves, alternate coil voltages and explosion-proof enclosures are available as options. Consult price list or nearest Temescal sales office for complete information.

Note: Special "O" Ring materials are available as options. Consult price list or nearest Temescal sales office for complete information.

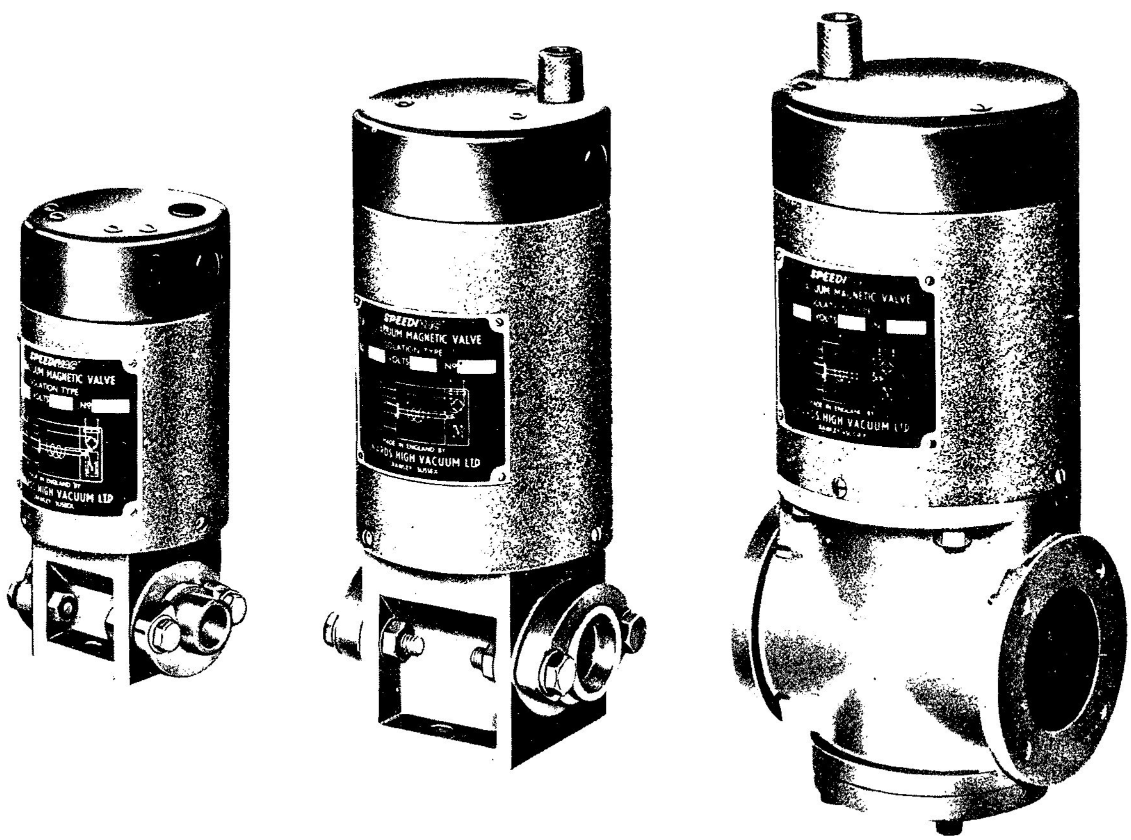
TEMESCAL
metallurgical corp

2850 SEVENTH STREET, BERKELEY, CALIFORNIA 94710 • PHONE: (415) 841-5720 • FAX: FGC

Regional Offices: 10515 South Western Avenue, Chicago, Illinois 60643 • Phone (312) 233-0232 Merwin Building, Wilton, Connecticut 06897 • Phone: (203) 762-8361

Figure 21. High Vacuum Valves With Specifications (Temescal) (Sheet 2 of 2)

Pipeline valves—solenoid operated



Of the Edwards range of solenoid valves, three are for isolation only, one combines isolation of the pipeline with air admittance to one side of it and one combines isolation when shut with a water cooled plate baffle when open. Each valve is d.c. operated but has integral contact cooled rectifiers making it suitable for a.c. supply. The rectifiers can easily be by-passed when operation from a d.c. supply is required.
The valves are resistant to mercury vapour but are not suitable for systems pumping liquids or corrosive vapours. The finish is a grey hammer body, natural aluminium base and black cover. A bush is fitted for $\frac{3}{8}$ in conduit supply cable.
In proving trials in our laboratories test batches of these valves have completed more than four hundred thousand on/off cycles, equivalent to many years hard use, without appreciable wear. This great inherent reliability allows fully automatic systems to be operated with maximum dependability and full 'fail safe' protection.

Isolation valves

The three isolation valves in the Edwards range are made to similar patterns suitable for $\frac{1}{2}$ in, 1 in and 2 in pipelines. Each valve has three ports, one high pressure and two low pressure with a blind tailpiece to seal the port not in use. Straight through or right-angle connexions with a pipeline is possible. The valve resists and opens against a pressure differential greater than one atmosphere in either direction. It can therefore be used on low pressure applications up to 25 lb/in^2 (1.7 kg/cm^2) gauge pressure. A spring holds the valve closed when de-energised.
Two $\frac{1}{4}$ in B.S. Fine tapped holes, with screws, are provided in the underside of the body for attachment of the valve to a bracket or support. The valve can be mounted with the top cover in any position between vertical and horizontal, but not below horizontal.

Publication 08701-1

Figure 22. Solenoid Operated Isolation Valves With Specifications (Edwards)
(Sheet 1 of 2)

Pipeline connexions

½ in valve Two coupling tailpieces to suit 0.596 in o.d., 16 mm o.d. or ⅝ in o.d. tube and one blind tailpiece.
Alternative coupling tailpieces can be purchased to allow the valve to be connected to a 'free' (solderless) joint made with either 0.596 in or 0.625 in o.d. and 16 mm o.d. pipelines.

1 in valve Two coupling tailpieces to suit 1.112 in or 28 mm o.d pipe and one blind tailpiece.
Alternative coupling tailpieces can be purchased to allow the valve to be connected by soldering, brazing or welding into 1.125 in o.d. pipelines or to allow a 'free' (solderless) joint to be made into either 1.112 in and 28 mm or 1.125 in o.d. pipelines.

2 in valve Demountable flanges with 'O' ring seals to take 2.128 (54.2 mm) o.d. tube.

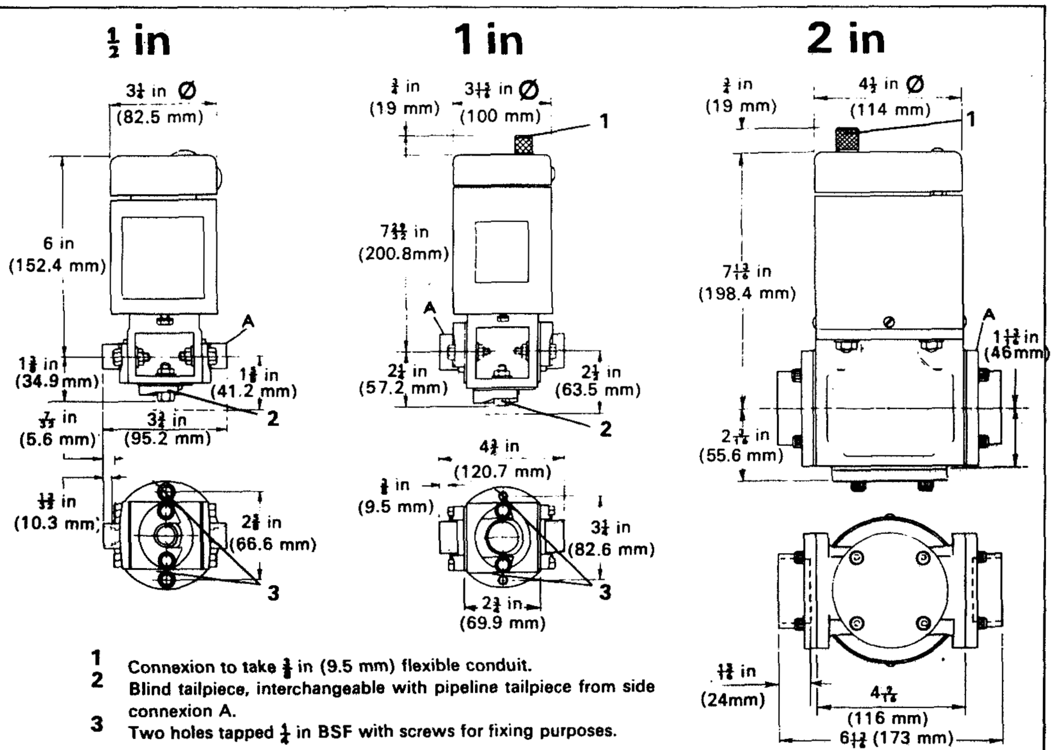
Principal data

		½ in	1 in	2 in
Leak rate across seat	torr litre/sec	10^{-7}	10^{-7}	10^{-6}
Leak rate through body	torr litre/sec	10^{-7}	10^{-7}	10^{-6}
Weight	lb	7.6	15	20
	kg	3.4	6.8	9

Ordering details

Size	Electricity supply	Code	Price
½ in	200-250V a.c. 50-60 c/s or 160-200V d.c.	D2120	
½ in	100-127V a.c. 50-60 c/s or 80-105V d.c.	D21201	
1 in	200-250V a.c. 50-60 c/s or 160-200V d.c.	D2130	
1 in	100-127V a.c. 50-60 c/s or 80-150V d.c.	D21301	
2 in	200-250V a.c. 50-60 c/s or 160-200V d.c.	D2160	
2 in	100-127V a.c. 50-60 c/s or 80-105V d.c.	D21601	

All of the above valves are covered by our exchange replacement scheme.



1 Connexion to take ⅜ in (9.5 mm) flexible conduit.
2 Blind tailpiece, interchangeable with pipeline tailpiece from side connexion A.
3 Two holes tapped ¼ in BSF with screws for fixing purposes.

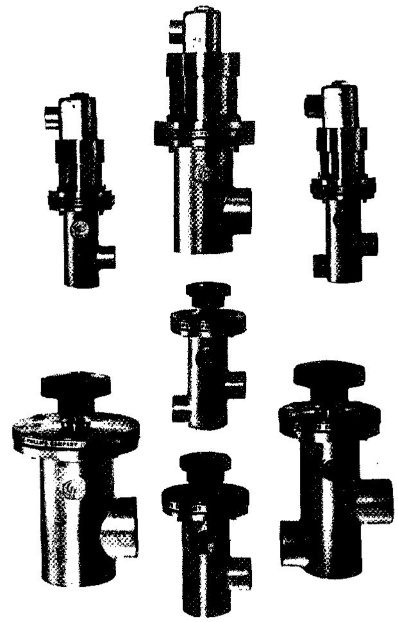
Figure 22. Solenoid Operated Isolation Valves With Specifications (Edwards) (Sheet 2 of 2)

08701-2

GRANVILLE-PHILLIPS COMPANY

Series 257 and 258

BELLOWS SEALED HIGH VACUUM VALVES



1. FORGED BRASS . . . free from porosity
2. HIGH OPEN CONDUCTANCE . . . nosepiece retracts completely clear of port opening
3. LOW SEALED CONDUCTANCE . . . less than 10^{-12} liter/sec.
4. INTERCHANGEABLE COMPONENTS . . . manual driver is interchangeable with air operated driver
5. EASE OF MAINTENANCE . . . sealing components are replaceable without removing valve from the system

APPLICATIONS

Granville-Phillips Bellows Sealed High Vacuum Valves are designed to provide reliable, mass spectrometer leak tight sealing in applications where bakeable valves are not required. Their low cost, compact size, sealing characteristics, and interchangeable drivers make them useful as vent, leak, roughing, and backfill valves in high vacuum systems.

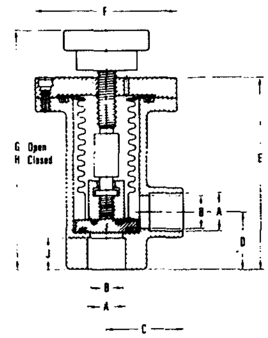
DESIGN

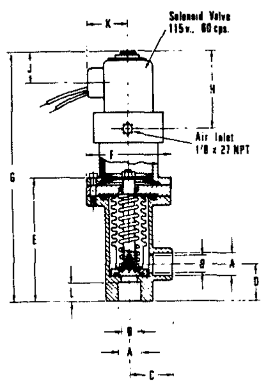
Each valve is precision machined from solid forged brass stock to minimize possible sources of outgassing. These valves will seal to less than 10^{-12} liter/sec. with high vacuum on either port and atmospheric pressure on the opposite port. High conductance is accomplished through a special, long stroke, bronze bellows which allows the nosepiece to lift completely clear of the inlet port. Extra convolutions and built in stops assure operation of the valve within safe limits thus promoting long bellows life. The seal is formed by compressing a nosepiece mounted Viton O-ring against the valve seat in the body. A second Viton O-ring is used as the seal between the driver assembly and valve body for a reliable, long lasting, vacuum tight connection. Manual and air operated valves are available in both the right angle and the in-line valve series in a variety of port sizes. These sizes range from 3/8 inch tube diameter to 1-5/8 inch tube diameter in the right angle series and from 3/8 inch tube diameter to 1-1/8 inch tube diameter in the in-line series. All valves have brazing type connections.

On air operated models, a three-way solenoid valve actuates the air cylinder. Valves are "normally closed", i.e. the valve is in its closed position when the solenoid valve is de-energized, which assures fail-safe operation in the event of a power failure. The air operated driver can be positioned throughout 360° in increments of 90°. An especially desirable feature is the interchangeability between air operated drivers and manual drivers in similar size valves. Only three manual or three air operated drivers are required to service all 18 different valve models. Manual and air operated drivers may be interchanged without removing the valve from the system. Nosepieces, bellows, or Viton O-ring seals can be replaced in the field without the need to replace a complete drive unit, and replacement parts are available from stock.

Figure 23. High Vacuum Valves, Manual and Solenoid With Specifications (Granville-Phillips) (Sheet 1 of 2)

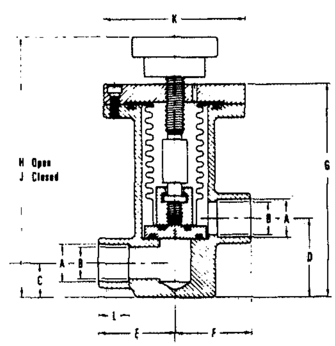
SERIES 257 – MANUAL CONTROL – RIGHT ANGLE VALVES									
CATALOG NO.	A	B	C	D	E	F	G	H	J
257 102	3/8	1/4	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 104	1/2	3/8	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 106	3/4	5/8	1-13/32	1-3/16	3-3/4	2-3/4	5-17/32	4-27/32	5/8
257 108	1-1/8	1	2-1/32	1-11/16	4-3/4	3-3/8	7-11/32	6-11/32	15/16
257 110	1-5/8	1-1/2	2	1-11/16	5-1/8	4-1/4	8-7/32	6-23/32	3/4

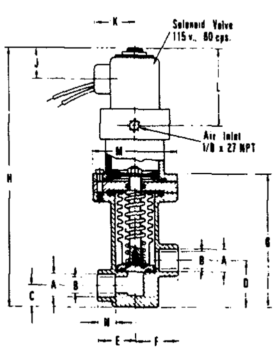




SERIES 257 – AIR OPERATED – RIGHT ANGLE VALVES											
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L
257 202	3/8	1/4	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 204	1/2	3/8	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 206	3/4	5/8	1-13/32	1-3/16	4	2-3/4	8-3/64	2-5/8	1-1/32	1-7/16	5/8
257 208	1-1/8	1	2-1/32	1-11/16	5	3-3/8	9-27/64	2-5/8	1-1/32	1-7/16	15/16
257 210	1-5/8	1-1/2	2	1-11/16	5-7/16	4-1/4	10-11/64	2-5/8	1-1/32	1-7/16	3/4

SERIES 258 – MANUAL CONTROL – IN-LINE VALVES											
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L
258 102	3/8	1/4	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 104	1/2	3/8	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 106	3/4	5/8	5/8	1-1/2	1-9/32	1-13/32	4-1/16	5-27/32	5-5/32	2-3/4	5/8
258 108	1-1/8	1	31/32	2-11/32	1-23/32	2-1/32	5-7/16	8	7	3-3/8	15/16





SERIES 258 – AIR OPERATED – IN-LINE VALVES														
CATALOG NO.	A	B	C	D	E	F	G	H	J	K	L	M	N
258 202	3/8	1/4	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 204	1/2	3/8	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 206	3/4	5/8	5/8	1-1/2	1-9/32	1-13/32	4-5/16	8-23/64	1-1/32	1-7/16	2-5/8	2-3/4	5/8
258 208	1-1/8	1	31/32	2-11/32	1-23/32	2-1/32	5-21/32	10-5/64	1-1/32	1-7/16	2-5/8	3-3/8	15/16

NOTE: All dimensions shown in inches. Granville-Phillips reserves the right to change design and specifications without notice.

Figure 23. High Vacuum Valves, Manual and Solenoid With Specifications (Granville-Phillips) (Sheet 2 of 2)

BULLETIN 10-4

HIGH-VACUUM GATE VALVES, TYPE VCS

CVC

FEATURES

- High-Density, Cast-Aluminum Bodies With Ultra-Smooth Internal Surfaces . . . Minimal Contamination
- Ungrooved Flanges And Con-O-Rings For Reduced Outgassing
- Choice of 2-, 4-, or 6-Inch Nominal Sizes, Each With Three Types of Interchangeable Operating Mechanism
- High Conductance

GENERAL

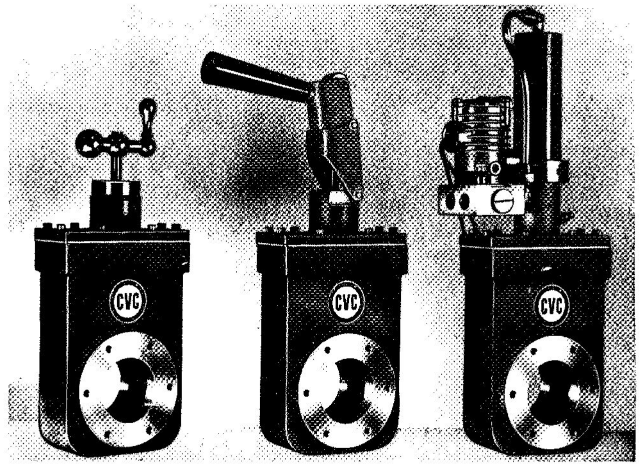
Gate valves for high-vacuum service offer many advantages. The full opening, straight-through flow path provides the highest conductance of any valve type. The thin design reduces the overall height of stacked components required for pumping systems. Gate valves can be mounted with either side towards atmosphere. In addition to these general advantages, CVC's type VCS gate valves have many specific advantages as listed in the following sections.

ULTRA-SMOOTH INTERIOR FOR LOW PRESSURE CAPABILITY

Aluminum melted and cast under vacuum provides high-density, non-porous valve bodies. Further heat treating stabilizes the casting for later machining. Smooth interior finish (100 micro-inch RMS average), which is two to three times smoother than other aluminum gate valves, greatly reduces outgassing. Total outgassing from the valve is the sum of all vacuum surfaces. Smoother surface has less area to pick up and hold contaminants and can be more easily cleaned if it should become contaminated. Operation at pressures in the low 10^{-8} torr range is routine.

DECREASED OUTGASSING WITH UNGROOVED FLANGES

CVC's gate valves have flat flanges . . . there are no gasket grooves which can trap atmospheric gases and release them into the system. The Con-O-Ring gaskets (elastomer O-rings held in aluminum retainer rings) which seat on these flat surfaces have greater versatility in orientation and location than conventional O-rings. Buna-N elastomers are routinely supplied in Con-O-Rings; Viton-A elastomers are available on order.



One piece valve body castings eliminate gasketed body joint . . . decrease potential outgassing and leakage.

FULL OPENING . . . HIGH CONDUCTANCE

The full-opening valves in the VCS series have large unobstructed passages and short flange-to-flange dimensions to give high conductances and decrease pumpdown time. Flange drillings match 150# ASA standards to provide interchangeability and ease of installation.

LONG OPERATING LIFE

Dependable, long-term operation is assured with VCS valves. The valve plate is guided by rollers and connected to a follower carriage by two hinged links. Sound mechanical design and construction provide extremely long operating life. A six-inch valve with manual throttling operator passed a 30,000-cycle life test with no sign of failure.

VACUUM-TIGHT IN EITHER DIRECTION

Each type VCS valve is tested in a static condition with a helium-sensitive mass-spectrometer leak detector. The permissable in-leakage rate is 1 x 10^{-8} atmospheric cc per second or less. Valves can be installed so the plate closes upwards or downwards without affecting operation.

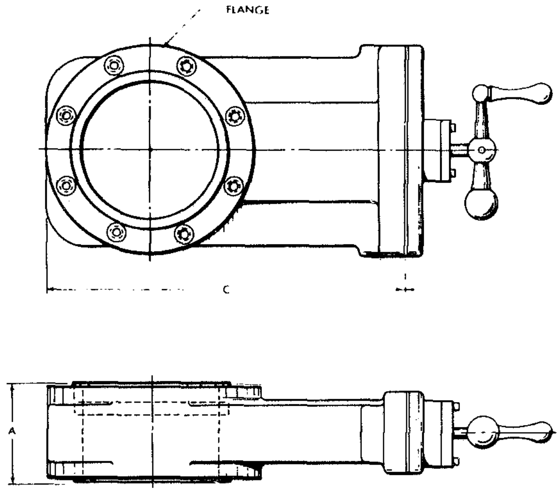
Consolidated Vacuum Corporation

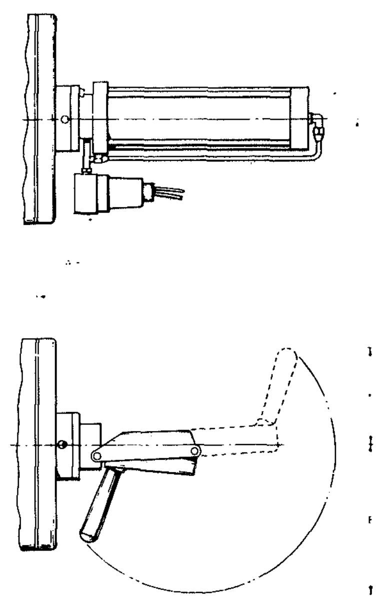
Figure 24. High Vacuum Valves, Gate, Right Angle Manual and Solenoid Operated With Specifications (CVC) (Sheet 1 of 4)

THREE TYPES OF OPERATING MECHANISM

Three types of operating mechanism are available: manual throttling which incorporates an Acme-threaded actuating shaft; manual quick-acting which utilizes a double toggle for rapid actuation; and pneumatic which employs a double-acting air cylinder for remote control. Each type will seal vacuum-tight against atmospheric pressure acting in either direction and is easily actuated against atmosphere. Pneumatic operators are connected so the VCS valve is normally closed and require 7.7 watts at 115 volts, 60 cycles for operation. Solenoid air connections are $\frac{1}{4}$-inch FPT.

The operating mechanism is mounted on an easily removable end plate and can be quickly removed for servicing or cleaning without disconnecting the body casting from the vacuum line. Operating mechanisms are easily interchangeable in valves of the same nominal size. Operator conversion kits are available.





DATA TABLE (Dimensions in inches)

NOMINAL SIZE	TYPE*	A**	B	C	D	E	F	G	H	FLANGE OD	FLANGE ID	FLANGE BC	HOLES NO.	HOLES SIZE	HOLES OFFSET†	WEIGHT (LB) NET	WEIGHT (LB) SHIPPING
2″	VCS-21A VCS-22A VCS-23A	$2\frac{5}{8}$	5	$7\frac{3}{16}$	Throttle—$5\frac{1}{16}$ Quick—$9\frac{7}{8}$ Pneumatic—$8\frac{13}{16}$	$5\frac{3}{4}$	$5\frac{1}{8}$	$4\frac{5}{16}$	$1\frac{15}{32}$	4	$2\frac{1}{4}$	$3\frac{5}{16}$	6	$\frac{5}{16}$-18 NC	none	Throttle—$6\frac{1}{2}$ Quick—7 Pneumatic—9	9 9 13
4″	VCS-41B VCS-42A VCS-43A	$4\frac{7}{16}$	9	$14\frac{13}{16}$	Throttle—$6\frac{3}{8}$ Quick—$14\frac{15}{16}$ Pneumatic—$13\frac{11}{16}$	$7\frac{1}{8}$	5	$4\frac{13}{16}$	$2\frac{5}{16}$	9	$5\frac{1}{4}$	$7\frac{1}{2}$	8	$\frac{5}{8}$-11 NC	$22\frac{1}{2}°$	Throttle—$30\frac{1}{2}$ Quick—$31\frac{1}{2}$ Pneumatic—36	36 36 43
6″	VCS-61B VCS-62A VCS-63A	$4\frac{3}{4}$	11	$18\frac{3}{4}$	Throttle—$7\frac{1}{2}$ Quick—$15\frac{1}{2}$ Pneumatic—$16\frac{3}{8}$	$7\frac{1}{2}$	5	$5\frac{7}{16}$	$2\frac{13}{32}$	11	7	$9\frac{1}{2}$	8	$\frac{3}{4}$-10 NC	$22\frac{1}{2}°$	Throttle—44 Quick—42 Pneumatic—49	51 51 60

*Type numbers ending in 1 designate manual throttling operator; numbers ending in 2 designate quick-acting; numbers ending in 3 designate pneumatic.

**Add 0.102″ for each Con-O-Ring.
†Bolt-hole offset is measured from the vertical in drawing.
Required air pressure for pneumatic operators is 40-60 psig.

12M964

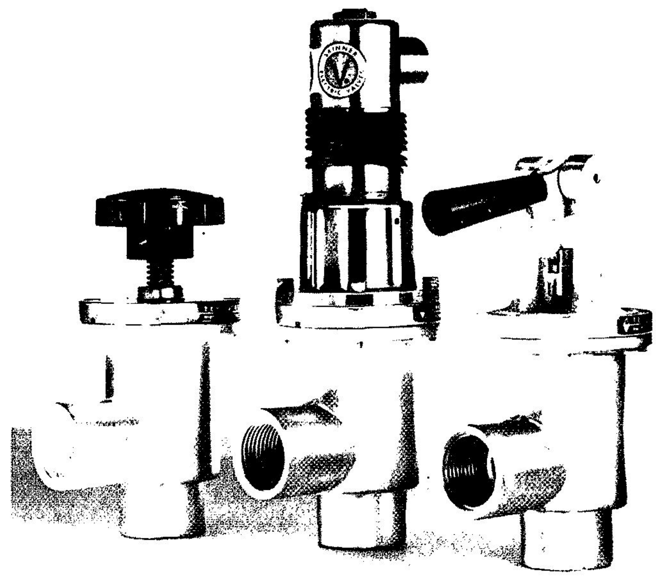
Figure 24. High Vacuum Valves, Gate, Right Angle Manual and Solenoid Operated With Specifications (CVC) (Sheet 2 of 4)

BULLETIN 10-6

HIGH-VACUUM RIGHT-ANGLE VALVES, type VRA (½"-1½")

FEATURES

- Three Nominal Sizes Available From Stock
- Removable Operating Mechanism . . . No Need to Break Vacuum Lines
- Low-Pressure Capability . . . Operate Successfully At Pressures As Low As 10^{-8} Torr Range
- Air-Operated Models For Remote Control Have Fail-Safe Feature



VRA type valves are available in two size ranges. The ½-inch thru 1½-inch valves are described below. Twenty-inch and thirty-five-inch valves are available and are described in Bulletin 10-7.

The small VRA valves have forged bronze bodies. Internal mechanisms constructed of wear-resistant metals contribute to long operating life. The valves will seal against a pressure differential of 15 psig in either direction and can be mounted in any position. Each valve is leak tested on a mass spectrometer type leak detector to assure leak tightness. Air operated models are fail-safe; if there is a power or air pressure failure, the valve closes.

CHOICE OF VACUUM CONNECTIONS

These valves are available with either FPT connections or female sockets for soldering to the vacuum line. Leak tightness of the connections depends upon installation technique and either style may be made equally tight. However, solder connections are normally used for the lower pressure requirements.

MANUAL OR AIR OPERATORS

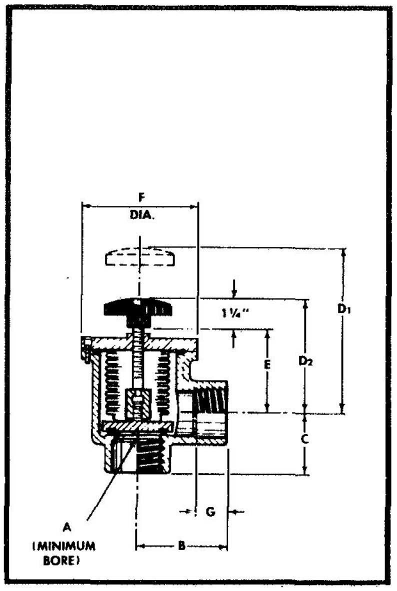
A choice of threaded, lever, or pneumatic operators is also available with each valve. All operators are connected to the valve body by a flanged joint sealed with an O-ring. Operators are interchangeable, and can easily be removed without breaking the vacuum line connections.

REQUIRED SERVICES

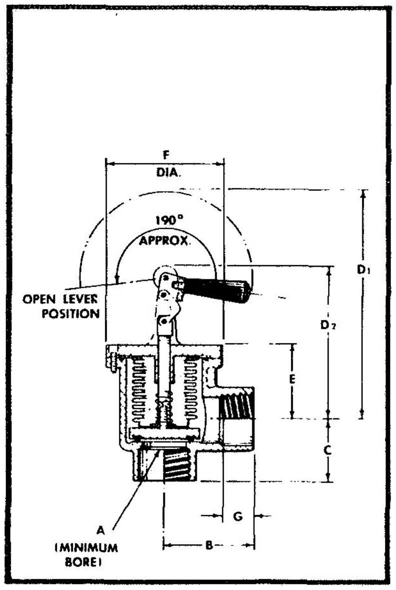
The air-operated models require 115-volt, 60-cycle electrical service and draw 10 watts. They also require compressed air service of 60 psig minimum and 125 psig maximum. The ½-inch FPT conduit connection can be rotated through 360°. The ⅛-inch FPT air connection can be rotated through 360° in 90° increments.

Consolidated Vacuum Corporation

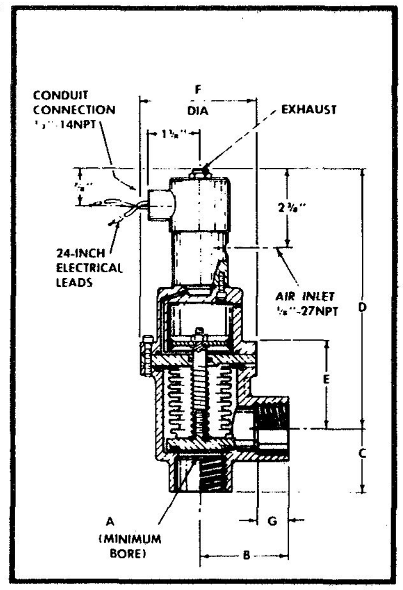
Figure 24. High Vacuum Valves, Gate, Right Angle Manual and Solenoid Operated With Specifications (CVC) (Sheet 3 of 4)



THREADED OPERATOR



LEVER OPERATOR



PNEUMATIC OPERATOR

NOMINAL SIZE	TYPE	OPERATOR	A (Minimum Bore)	B	C	D		E	F	G	PORT SIZE		NO. OF TURNS TO OPEN	NET WEIGHT (LB.)
						D_1	D_2				PIPE TAP	TUBING (OD)		
½"	VRA-51A	Threaded	⅝	1¾	1 5/16	3¾	3 5/16	1 11/16	2¾	—	½ FPT	—	3¼	2
½"	VRA-54A	Threaded	39/64	1¾	1 5/16	3¾	3 5/16	1 11/16	2¾	¾	—	¾	3¼	2
½"	VRA-52A	Lever	⅝	1¾	1 5/16	6⅞	4⅜	1 11/16	2¾	—	½ FPT	—	—	2
½"	VRA-55A	Lever	39/64	1¾	1 5/16	6⅞	4⅜	1 11/16	2¾	¾	—	¾	—	2
½"	VRA-53A	Pneumatic	⅝	1¾	1 5/16	6 11/16		1 15/16	2¾	—	½ FPT	—	—	3¼
½"	VRA-56A	Pneumatic	⅝	1¾	1 5/16	6 11/16		1 15/16	2¾	¾	—	¾	—	3¼
1"	VRA-11A	Threaded	1	2 5/16	1¾	4 15/16	4 1/16	2 9/16	3	—	1 FPT	—	5¼	3¾
1"	VRA-14A	Threaded	1	2 5/16	1¾	4 15/16	4 1/16	2 9/16	3	⅞	—	1⅛	5¼	3¾
1"	VRA-12A	Lever	1	2 5/16	1¾	7¾	5¼	2 9/16	3	—	1 FPT	—	—	3½
1"	VRA-15A	Lever	1	2 5/16	1¾	7¾	5¼	2 9/16	3	⅞	—	1⅛	—	3½
1"	VRA-13A	Pneumatic	1	2 5/16	1¾	7½		2 13/16	3	—	1 FPT	—	—	5¼
1"	VRA-16A	Pneumatic	1	2 5/16	1¾	7½		2 13/16	3	⅞	—	1⅛	—	5¼
1½"	VRA-151A	Threaded	1½	2¾	2 3/16	5⅜	4¼	2 13/16	3⅞	—	1½ FPT	—	6¼	6¾
1½"	VRA-154A	Threaded	1½	2¾	2 3/16	5⅜	4¼	2 13/16	3⅞	1	—	1⅝	6¼	6¾
1½"	VRA-152A	Lever	1½	2¾	2 3/16	8	5½	2 13/16	3⅞	—	1½ FPT	—	—	6
1½"	VRA-155A	Lever	1½	2¾	2 3/16	8	5½	2 13/16	3⅞	1	—	1⅝	—	6
1½"	VRA-153A	Pneumatic	1½	2¾	2 3/16	8 7/16		3 1/16	3⅞	—	1½ FPT	—	—	8½
1½"	VRA-156A	Pneumatic	1½	2¾	2 3/16	8 7/16		3 1/16	3⅞	1	—	1⅝	—	8½

12M767 Figure 24. High Vacuum Valves, Gate, Right Angle Manual and Solenoid Operated With Specifications (CVC) (Sheet 4 of 4)

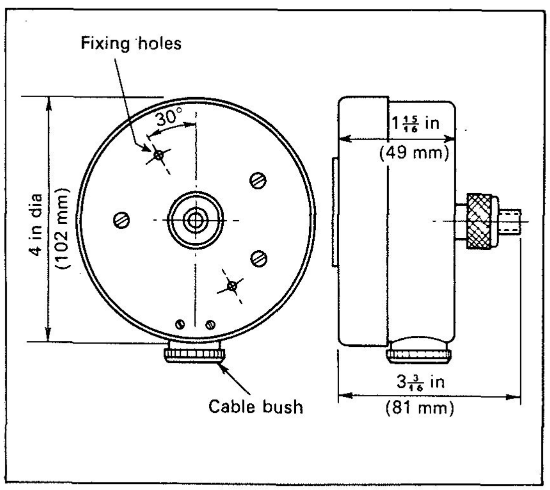
Vacuum switch
Model VSK1B

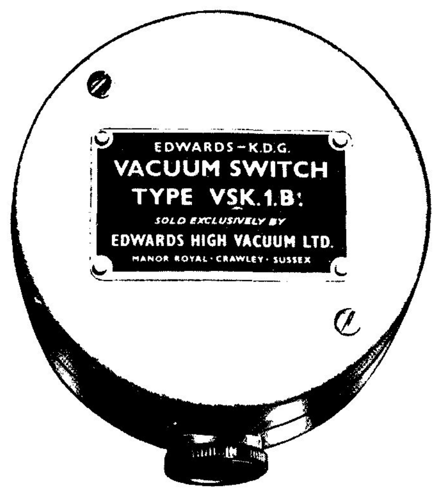
Range: 25 to 760 torr

Switching differential	Within 25 torr
Switch contact rating	250V 5A
Volume added to system	4.2 cm^3
Maximum working pressure	15 lb/in^2 (1.05 kg/cm^2)

A capsule operated microswitch for direct connexion to the vacuum system, providing on-off control of electrical circuits at any preset pressure between 25 to 760 torr. The Switch is not barometrically independent.

Electrical connexion	$\frac{3}{4}$ in (19 mm) conduit bush for cable entry to terminal block
Net weight	1 lb 1 oz (482 g)
Finish	Grey hammer
Mounting	To plate or bracket by two fixing holes in back of case. Fixing holes $\frac{5}{32}$ in (4 mm) dia on a 3 in (76 mm) PCD 30° offset from vertical centre line.
Vacuum connexion	$\frac{1}{4}$ in (6.3 mm) entry of $\frac{1}{8}$ in (3.2 mm) nominal bore · 0.205 in (5.4 mm) o.d. copper tube to BS659.





Ordering details

Model	Description	Code	Price
VSK1B	Vacuum switch	D5908	

Publication 07722–1

Figure 25. Vacuum Switches With Specifications (Edwards) (Sheet 1 of 2)

Vacuum switch Model VSK6

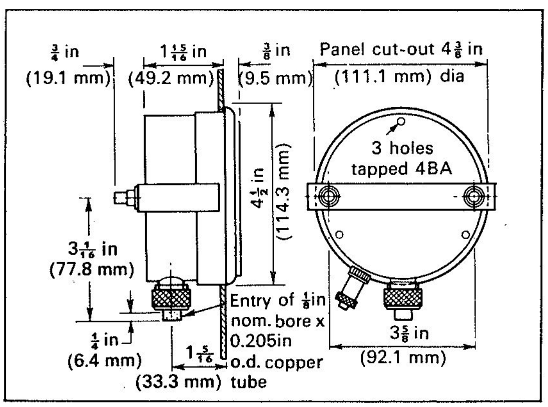
Relay unit Model VS6

Range: 0–20 torr and 0–100 torr

Switching differential	Within ± 1% of range
Volume added to system 240 cm³	
Electrical connexion	By special cable (supplied) to Model VS6 Relay Unit
Net weight	4 lb (1.8 kg)
Finish	Grey hammer
Mounting	Panel (flush) using bracket provided
Vacuum connexion	$\frac{1}{4}$ in (6.3 mm) entry of $\frac{1}{8}$ in (3.2 mm) nominal bore × 0.205 in (5.4 mm) o.d. copper tube to BS659

The Vacuum Switch and the Relay Unit, although sold separately, are intended to operate together using the interconnecting coaxial cable provided to provide a high sensitivity ON/OFF vacuum actuated relay.

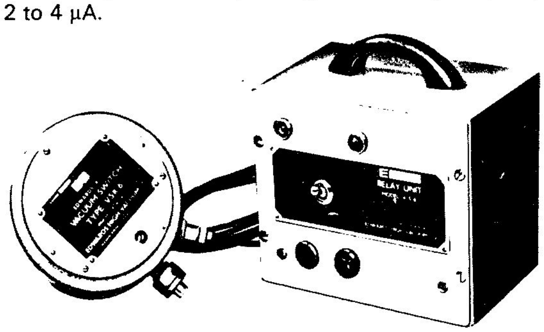
The VSK6 Switch is barometrically independent and contains a capsule sealed within a metal case which is in communication with the vacuum system. Movement of the capsule operates a pair of very light contacts. The switching level is adjusted by a setting screw on the front panel, the selected pressure appearing in a window in the case cover. Setting accuracy is within ±5% of range.



Range: as Vacuum switch VSK6

Switching levels	One	
Relay contact ratings (non-inductive load)	Changeover	5A 230V a.c. 2.5A 230V d.c.
Dimensions	$5\frac{1}{16}$ high × $6\frac{7}{16}$ wide × $4\frac{3}{16}$ in deep (129 × 164 × 106 mm)	
Net weight	$5\frac{1}{4}$ lb (2.4 kg)	
Finish	Grey hammer	
Mounting	Bench or panel (flush)	
Leads supplied	6 ft (1.8 m)	Electricity supply coaxial to VSK6 switch, complete with matching plugs
Front panel mounting details	See page 07725-2	

The Relay Unit, controlled by the VSK6 Switch, contains a thyratron operated relay with contacts for external use. Indicator lamps show the relay state. The operating current required for relay changeover is very low, only 2 to 4 μA.



Ordering details

Model	Description	Code	Price
VSK6	Vacuum switch, 0–20 torr	H360	
VSK6	Vacuum switch, 0–100 torr	H3602	
VS6	Relay unit	D13601	

Edwards research leads to continuous improvement; details of products supplied may therefore vary from those described.

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Printed in England GDOB2; 768

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Figure 25. Vacuum Switches With Specifications (Edwards) (Sheet 2 of 2)

Relay unit Model VS9-1

for use with Pirani gauges Models 8–1, 8–2, B5 and Ionization-Pirani gauge Model 1.

Range: That of the gauge to which it is connected

The Model VS9–1 Relay Unit provides control of a slave relay, heavy duty contactor or other apparatus from any of the following Edwards Pirani gauges:

Model B5

Models 8–1 and 8–2 including the Multihead switch unit

Model 1 Ionization-Pirani gauge (Pirani section)

The VS9–1 Relay Unit has no switch head and has no connexion to the vacuum system. The Unit has two switching levels, but no pressure limitations as it covers the full pressure range of the gauge to which it is connected.

Variations in system pressure cause voltage variations in the Pirani gauge and these same voltages operate a relay in the Unit, which has two uncalibrated controls on the front panel to select upper and lower pressure levels. Each control covers the full pressure range of the Pirani gauge and can be set against the Pirani gauge readings. When the system pressure falls to the selected low pressure level the relay energises; as pressure rises the relay de-energises at the high pressure setting. The two controls can be set to virtually the same pressure so as to obtain a very narrow differential.

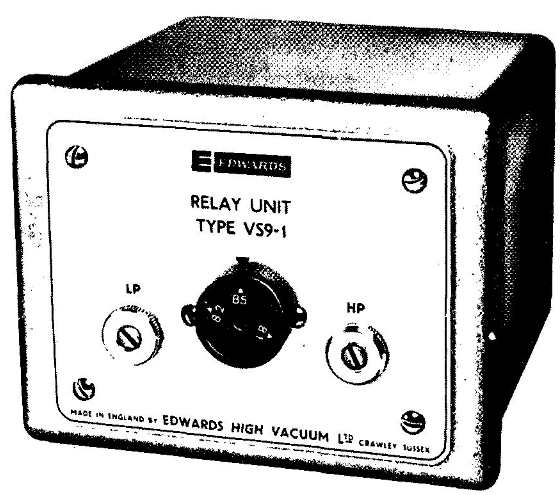
The relay is always energised at low pressure and de-energised at high pressure, so as to give 'fail-safe' protection.

A selector on the front panel of the Relay Unit is set to match the Pirani gauge, and the Unit is connected to terminals on the gauge. (A terminal block must be added to the 8–1 and 8–2 series gauges at present.)

Two pairs of external-use heavy-duty contacts, one pair normally open and one pair normally closed, and a set of changeover contacts to operate an external indicator are provided. The contacts have no internal power supply.

The Relay Unit has four tapped holes provided in the base of the die-cast aluminium case for attachment to a bracket.

Switching levels	Two, anywhere within the range	
Repeatability		
Model 8–1	Range 1 (HP) ±8% fsd Range 2 (LP) ±1% fsd	
Model 8–2	Range 1 (LP) ±10% fsd Range 2 (HP) ±1% fsd	
Model B5	±3% fsd	
Ionization-Pirani Model 1	±3% fsd	
Relay contact ratings (non-inductive load)		
	Heavy Duty N.C. & N.O.	5A 250V a.c. 5A 25V d.c.
	Changeover	0.5A 250V a.c. 0.5A 25V d.c.
Dimensions	$4\frac{1}{16}$ high × $5\frac{1}{4}$ wide × $5\frac{1}{2}$ in deep (103 × 133 × 140 mm)	
Net weight	3 lb 4 oz (1.47 kg)	
Finish	Grey hammer, with satin aluminium front panel	
Mounting	Bench, panel (flush) or bracket	
Leads supplied	6 ft (1.8 m) electricity supply	
Front panel mounting details	See page 07725-2	



Ordering details

Model	Description	Code	Price
VS9–1	Relay unit for Pirani gauges	D19101	

Figure 26. Relay Units, Remote Pressure Readout (Edwards) (Sheet 1 of 2)

Relay unit Model VS9-2

for use with Penning gauge Model 7 and Pirani-Penning gauge Model 4.

Range:

That of the gauge to which it is connected

The VS9–2 relay unit is designed for use with a Penning vacuum gauge to provide control of a slave relay, heavy duty contactor or other apparatus, and has adjustable high and low pressure switching levels. The relay unit has no pressure limitations, but covers the full pressure range of the Penning gauge to which it is connected, by rear panel terminals.

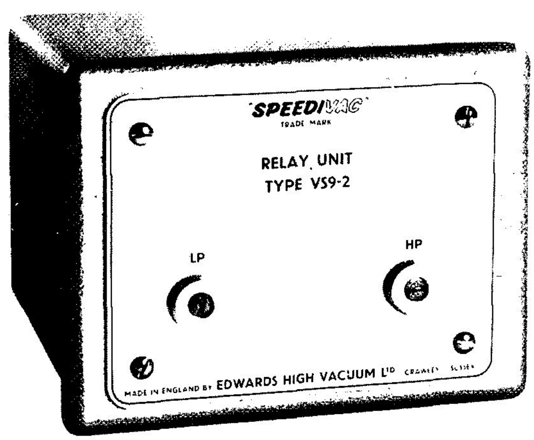
Two uncalibrated controls on the front panel, select the upper and lower pressure levels at which the relay is required to operate, each control covering the full pressure range of the Penning gauge. The controls are set against the pressure indication on the Penning gauge in use.

When the system pressure falls to the chosen low pressure level the relay energises. As pressure rises to the selected high pressure level the relay de-energises. The two controls can be set to the same pressure so as to obtain a very narrow differential. The relay is always energised at low pressure and de-energised at high pressure to give 'fail-safe' protection.

Two pairs of heavy duty contacts, one pair normally open and one pair normally closed, and a set of change-over contacts to operate an external indicator, on non-inductive loads, are provided. The contact positions are shown pictorially on the rear panel label.

The relay unit can be bench or panel mounted. The die-cast aluminium case has a grey hammer finish with a natural satin polished aluminium front panel.

Electricity supply required	100–130 or 200–250V 50 or 60 c/s a.c.		
Relay contact ratings (non-inductive load)			
	Heavy duty		5A 250V a.c. 5A 25V d.c.
	Changeover contacts or indicator lamps		0.5A 250V a.c. 0.5A 25V d.c.
Fuse	250 mA glass cartridge		
Dimensions	$4\frac{1}{16}$ high × $5\frac{1}{4}$ wide × 5 in deep (103 × 133 × 127 mm)		
Net weight	3 lb 12 oz (1.7 kg)		
Finish	Grey hammer, with satin aluminium front panel		
Mounting	Bench or panel		
Leads supplied	6 ft (1.8 m) 3 core		
Front panel mounting details	See page 07725–2		



Ordering details

Model	Description	Code	Price
VS9–2	Relay unit for Penning gauges	D19102–1	

Edwards research leads to continuous improvement; details of products supplied may therefore vary from those described.

EDWARDS HIGH VACUUM INC.
A member of Edwards International Group
3279, GRAND ISLAND BOULEVARD
GRAND ISLAND, NEW YORK.
Telephone: Grand Island RR3-7553 Telex: 710-250-1350 Edhivac

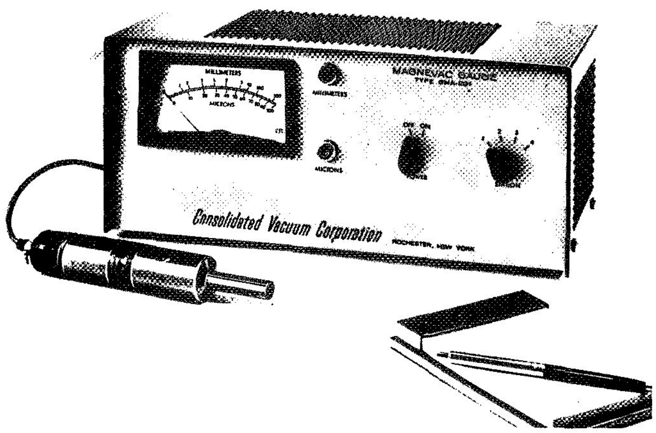
Figure 26. Relay Units, Remote Pressure Readout (Edwards) (Sheet 2 of 2)

BULLETIN 9-13

NEW MAGNEVAC® GAUGE FOR AUTOMATIC CONTROL

FEATURES

- Automatically Selects Range for Accurate Pressure Readout
- Controls External Circuits
- Solid-State Circuitry With Magnetic Amplifier Provides Highest Reliability
- Stable . . . Extremely Low Drift Assures Process Control At Set Pressure
- Monitors Pressure At Up To Four Different Locations
- Recorder Output
- Large, High-Sensitivity, Easy Reading Meter



GENERAL

The type GMA-201 Magnevac® gauge features automatic switching between the 0.1 mm Hg to 500 mm Hg scale and the 1 to 100 micron Hg scale at 100 microns Hg. Labeled indicator lights on the front panel show which pressure scale should be read. The meter, which has a non-sticking movement, is calibrated in units of dry air pressure; calibration factors for other gases are available. Glow discharge which is often used for substrate cleaning in thin-film work does not affect the calibration of the gauge.

Solid-state circuitry provides highest reliability; the magnetic amplifier assures stable operation and extremely low drift. High sensitivity is maintained by constant-temperature operation of the sensing-tube filament.

All calibration adjustments are easily accessible and plainly identified on the back panel. Precision calibrating potentiometers help eliminate the erratic behavior which is characteristic of many thermal conductivity gauges.

The gauge uses no radioactive material, so involved licensing and bulky shielding to eliminate radiation hazard are not required.

AUTOMATIC CONTROL OF EXTERNAL CIRCUITS

The automatic control circuit of the Magnevac gauge is set to trip if the pressure rises above 50 microns Hg, but the trip point can be easily adjusted to any pressure between 10 microns Hg and 500 mm Hg. The control circuit is independent of the meter and operates on both pressure ranges. When the setting of the station selector switch is changed, the control circuit is automatically connected to the energized station. The control circuit does not lock; it resets automatically when the pressure is reduced below the trip point. Pressure differential between drop-out and pull-in of the relay is 5% of the angular deflection on the meter or 10 microns Hg, whichever is greater. One set of contacts of the DPDT relay is wired to a three-pin connector on the back panel of the cabinet. The other set of contacts is accessible inside the cabinet for wiring by the customer. A safety-type external circuit for turning off pressure-sensitive components, or automation circuitry for operating valves at a pre-selected pressure, may be plugged into this connector.

RECORDER CONNECTION

A jack on the rear panel of the gauge provides a pressure-responsive output of up to 500 millivolts DC and operates independent of the pressure range switch. A 10-, 50-, or 100-millivolt, high-impedance recorder with suitable attenuating network can be connected here to cover the whole pressure range of the gauge.

Consolidated Vacuum Corporation

Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 1 of 6)

ONE-TO-FOUR STATIONS

The type GMA-201 Magnevac gauge is available with one, two, three, or four pressure sensing stations. If a gauge is purchased with less than four stations, additional stations can be installed at any time without removing the gauge from its cabinet. Simply buy as many tubes and cables as needed, plug them into the connectors on the rear panel of the gauge, and make the required calibration adjustments.

STABLE ACCURATE OPERATION

Magnevac gauges are built to meet specifications which require an extremely low drift—no more than ±2% of full scale in 400 hours with line voltage variation of 115 volts ±10% and temperature variations of 25° ±10°C. Frequent recalibration and zero adjustment are not needed. When the gauge is properly calibrated, the accuracy at any point on either scale is better than ±5% of the reading. The sensing tubes must be mounted horizontally for satisfactory results at pressures above 10 mm Hg.

OPERATING PRINCIPLE

The Magnevac gauge is a thermal-conductivity-type gauge and utilizes a high-gain magnetic amplifier to maintain the filament of the sensing tube at a constant temperature (approximately 195°C). As the pressure changes, the heat transferred from the filament to the tube envelope also changes. The voltage required to maintain the filament at a constant temperature is indicated on a meter calibrated in units of dry air pressure.

GAUGE SPECIFICATIONS

Width .... 14-7/16"
Depth .... 7¼"
Height .... 6-9/16"
No. of Stations .... 1 to 4
Type of Mounting .... Cabinet (Panel Kit Available)
Normal Operating Range .... 15°C to 35°C (59°F to 95°F)
AC Power Input .... 20 Watts, 115/230 volt, 60 cycle (also available for 50 cycle use)
Meter Scale Ranges .... 1 to 100 microns Hg, 0.1 to 500 mm Hg
External Control Circuit
Operating Range .... 10 microns Hg to 500 mm Hg
Relay Differential .... 10 microns Hg or 5% of angular deflection of meter, whichever is greater.
Relay Contact Capacity ... DPDT, 2 amps, 115 volts AC or 24 volts DC. One pole wired to receptacle on rear panel. Other pole available inside cabinet.
Tube Type .... GMA-001 supplied with gauge; bakeable types available.
Tube Cable Length .... 10' (Other lengths available as accessories)
Net Weight .... 16 lb.
Shipping Weight .... 18 lb.

TUBE SPECIFICATIONS

TYPE	GMA-001	GMA-004 (with cable)	GMA-005 (with cable)
FILAMENT Material	Tungsten	Tungsten	Tungsten
ENVELOPE Material	Tin-plated copper	Kovar	Kovar
Length	5-19/32"	5½"	8-15/32"
O.D.	1⅜"	½"	½"
TUBULATION Material	Tin-plated copper	Kovar	Pyrex
Length	1⅜"	—	—
O.D.	½"	½"	½"
MAXIMUM BAKEOUT TEMP.	Not bakeable	500°C	400°C
PRESSURE RANGE	0 to 500 mm Hg	0 to 10 mm Hg	0 to 10 mm Hg

ORDER INFORMATION

When ordering, specify the following:

1. Magnevac Gauge GMA-201
   (Specify number of stations)
   (For 50-cycle Service, Order GMA-201S)
2. Panel Kit for Rack Mounting 267269
   (8¾"x19")
3. Extra-Long Tube Cables
   15' 267174-2
   25' 267174-3
   50' 267174-4
   100' 267174-5
   200' 267174-6
4. Connectors (For Installing Sensing Tubes In A System)
   For Installation In ½" FPT Hole 61079
   For Installation In 1-17/32" Clearance Hole AS-004
   For Soldering Or Welding To System
   (Brass) AC-002
   (Stainless Steel) AC-006
   Glass-to-Kovar Seal (For GMA-001 Tube) 68046

CVC Consolidated Vacuum Corporation
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SALES AND SERVICE OFFICES • Albuquerque, N. M., 141 Wyoming N. E., AMherst 8-9333 • Atlanta, Ga., 3272 Peachtree Rd. N. E., Phone 233-1171 • Columbus, Ohio, 1350 W. 5th Ave., Phone 488-1187 • Dallas, Tex., 433 Regal Row, MElrose 1-3700 • Des Plaines, Ill., 3150 Des Plaines Ave., Phone 299-7757 • Minneapolis, Minn., 7100 France Ave. S., Suite 23, Phone 922-5660 • Needham Heights, Mass., 45 Fourth Ave., Phone 444-4080 • Palo Alto, Calif., 4015 Fabian Way, DAvenport 1-3151 • Philadelphia, Penna., 2010 Oregon Ave., HOward 5-3773 • Rochester, N. Y., 1775 Mt. Read Blvd., GLadstone 8-2550 • Springfield, N. J., 26 Linden Ave., DRexel 6-4900 • Van Nuys, Calif., 5430 Van Nuys Blvd., Phone 788-7300 • **INTERNATIONAL DIVISION:** Rochester, N. Y., 1775 Mt. Read Blvd., GL 8-2550 • Bell & Howell GmbH, Consolidated Electrodynamics Division, P. O. Box 345, Friedberg (Hessen), West Germany, Telephone (06031) 3441 • Bell & Howell Ltd., Consolidated Electrodynamics Division, 14 Commercial Road, Woking, Surrey, England, Telephone: Woking 5633

Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 2 of 6)

BULLETIN 9-9

SENSAVAC® CONTROLLER, Type GS-100

CVC

- Automatically Maintains a Specific Pressure–Indicates a Process–Signals a Warning–Adjusts Liquid Nitrogen Level.
- Operates with Any Electronic CVC Vacuum Gauge or Equivalent.
- Reliable Solid-State Magnetic Amplifier Insures Long Trouble-Free Operating Life.
- High Stability...Trip Point Remains at Set Value Without Drifting.
- Two-Point Control at Any Preset Pressure.
- Visual Indication of Switching Mode.
- Panel-Mount Accessory Available.

OPERATING PRINCIPLE

The GS-100 utilizes a high-gain, magnetic-amplifier-type control circuit which responds to the small input signals readily available from conventional vacuum gauges. The output of the control circuit drives a power relay for alarm or control purposes.

The operation of this control circuit is simple and reliable. Power is fed from the power line through the transformer to the gate windings and rectifiers of the magnetic amplifier and then to the control relay. In this condition, the cores of the magnetic amplifier are unsaturated. Very little power passes through to the relay, and the contacts are open. When a small current, provided by a connected high-vacuum gauge or other metering circuit, flows through the control (input) winding of the magnetic amplifier, the cores become magnetically saturated. Current passes freely to the relay and the contacts close. Because of the high power gain of the magnetic amplifier, about 2×10^5, a very small current in the control winding will operate the relay and the GS-100 controller can be connected in series with all types of metering circuits without appreciable effect on their calibration.

A bias coil permits adjustment of the relay trip point. This coil carries a fixed current which biases the cores magnetically to a preset level. Thus the input coil furnishes only the additional energy required to complete the magnetic saturation. The relay can be operated by any input current throughout the 0 to 200 microamp range by proper adjustment at the bias current. Pilot lights indicate the position of the relay contacts.

Consolidated Vacuum Corporation

Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 3 of 6)

ADVANTAGES OF THE GS-100 CONTROLLER

The GS-100 controller has many desirable characteristics. Input overloads up to 10,000% of maximum rating will not harm the circuit. The trip point of the controller is adjustable over a wide range of input signal values. It is stable; once the trip point has been set, it remains at the set value for long periods of time. The GS-100 is insensitive to normal line voltage variations and changes in ambient temperature. It will operate from the small input signals available from conventional high-vacuum gauges. The pressure at which the relay is activated as pressure rises is higher than that at which deactivation occurs as pressure falls. This pressure differential is adjustable and at maximum sensitivity is small enough to achieve precise control. At minimum sensitivity, the pressure differential is approximately equal to a 50% change in angular deflection of the connected vacuum gauge. The GS-100 does not interfere with normal operation or calibration of the metering circuit which provides the input signal. Any change in vacuum-gauge calibration resulting from connection of the controller will be 2% or less except in the case of thermocouple gauges which must be recalibrated after the controller is connected.

PRESSURE CONTROL APPLICATIONS

The GS-100 controller can be used for many control applications. It will turn the heater of a diffusion pump on or off. It will operate an audio or visual alarm circuit to signify a rise or fall of pressure. It will also open or close valves for automatic process control. Some of the possible control applications are shown schematically below.

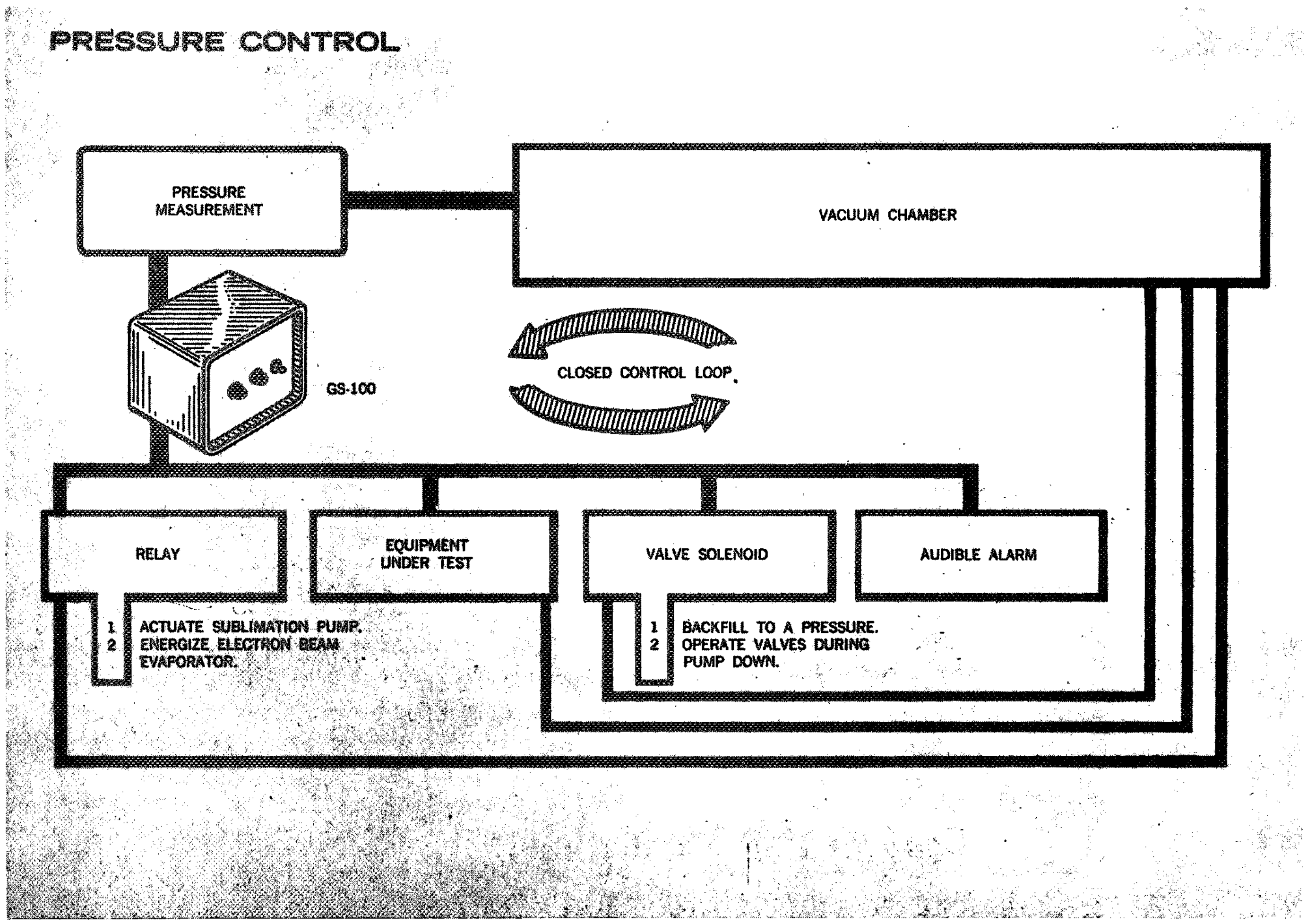


Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 4 of 6)

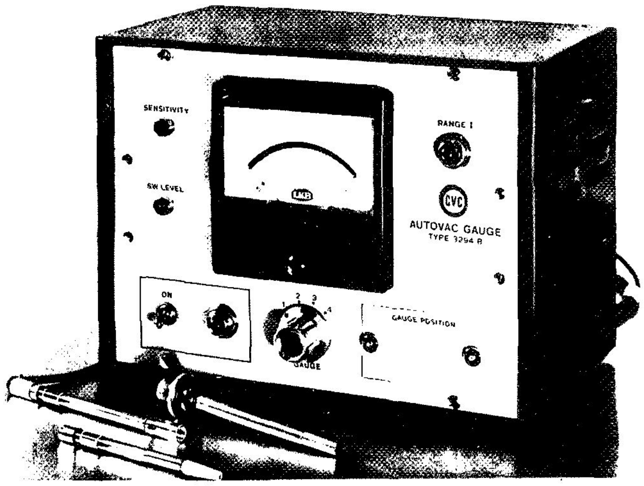
BULLETIN 9-8

AUTOVAC® HIGH-VACUUM GAUGE

CVC

FEATURES

- **Wide Range of Pressure Measurement... 100 Torr to 10^{-3} Torr**
- **Two Scales With Adjustable Automatic Range Switching**
- **Bakeable Sensing Tube Available**
- **Recorder Terminals**
- **Screw-Driver Adjustment Provides Choice of Five Line Voltages**
- **Accessory Panel Kit For Rack Mounting**
- **Control of External Circuits Possible With Accessory Relay and Connector.**



GENERAL

The Autovac gauge is a Pirani-type instrument with one-to-four stations and a choice of four types of sensing tube. The gauge covers the 1x 10^{-3} to 100 Torr pressure range on two scales calibrated in units of dry air pressure from 0.1 to 100 Torr and 1x10^{-3} to 0.1 Torr, respectively. A third scale is provided for measuring pressures of gases other than air. Calibration factors for many commonly used gases are supplied in the gauge instruction manual. The gauge meter has a lance-shaped pointer and mirror for increased readability. A pilot light indicates when the pressure lies within the range of the upper scale.

The gauge changes ranges automatically at a preset pressure of 0.1 Torr. This switch point can be adjusted to any pressure in the 0.1 to 0.5 Torr range by means of a set-screw on the front panel. An accessory relay and connector (GAV-003) can be used in conjunction with the range switch to activate external circuits for protection or control applications. The relay contacts are rated for 6 amps at 250 volts.

The Autovac gauge can be used to locate leaks. An adjustment on the front panel provides increased sensitivity for leak checking in the portion of the pressure range where the sensitivity of the gauge is normally low.

GAUGE SPECIFICATIONS

Width	12¼″	Depth	6¾″
Height	8½″	No. of Stations	1 to 4
Type of Mounting	Cabinet (Panel Kit Available)		
Power Input	50 watts		
Line Voltage	Screw-driver adjustment for 110, 130, 150, 220, or 240		
No. of Meter Scales	3		
Scale Ranges	1 to 100 microns Hg, 0.1 to 100 mm Hg, 0 to 100 microamps		
Tube Types	GAV-001, -004, -005, -006		
Tube Cable Length	6½′		
Net Weight	17 lb.	Shipping Weight	21 lb.
Recommended Recorder	High impedance, 10MV input		

Consolidated Vacuum Corporation

Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 5 of 6)

TUBE SPECIFICATIONS

Type	GAV-001	GAV-004*	GAV-005**	GAV-008
Application	General use	Glass Systems	Corrosive agents	Inert gas
Maximum Ambient Temperature	95°C	400°C	95°C	95°C
Envelope Material	Lead glass	Pyrex glass	Stainless Steel	Sodium Glass
Length	5″	5″	5½″	4⅞″
Volume	4 milliliters	4 milliliters	8 milliliters	1.5 milliliters
Tubulation O.D.	⅜″	⅜″	⅜″	5/16″ to 3/16″ std. taper
Electrical Connection	Bayonet type	2 tungsten pins	Amphenol (2 pins)	Bayonet type
Matching Connector Cable Type	GAV-002	GAV-006	GAV-007	GAV-002

***Bakeable to 400°C** ****Accessory compression connector available**

ORDER INFORMATION

When ordering, specify the following:

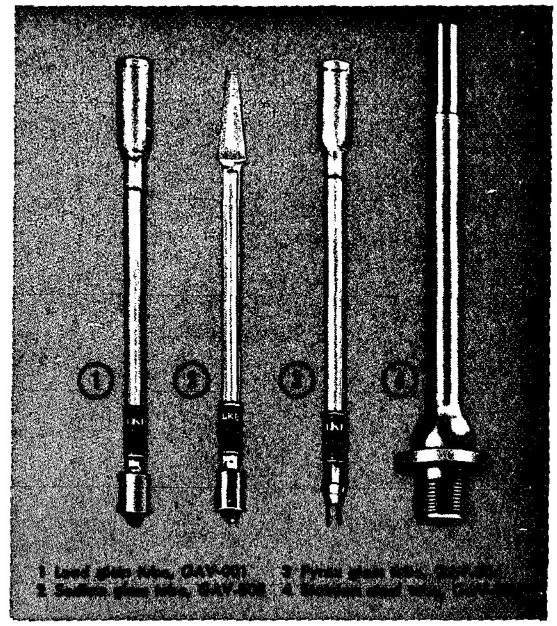
Item	*Order No.*
1. Gauge	
1 to 4 Station with Lead Glass Tube	3294B*
1 to 4 Station with Pyrex Glass Tube	3294B*
1 to 4 Station with Sodium Glass Tube	3294B*
1 to 4 Station with Stainless Steel Tube	3294B*

***Specify no. of stations and type of tube required**

2. Accessories as Required:

Panel Kit for Rack Mounting	62902
Accessory Relay and Connector	GAV-003
Tube Connector—Quick Disconnect with ½″ MPT	61083 and 61081-2
Extra Long Tube Cables (Installed)—	

	For GAV-001 and GAV-008 Tubes	*For GAV-004 Tube*	*For GAV-005 Tube*
15′	60604-2	68744-2	68745-2
25′	60604-5	68744-3	68745-3
50′	60604-3	68744-4	68745-4
100′	60604-4	68744-5	68745-5
200′	60604-7	68744-6	68745-6



CVC'S LINE OF HIGH-VACUUM GAUGES

The CVC line of precision high-vacuum gauges covers every conceivable requirement in the atmosphere to $2x10^{-10}$ Torr pressure range. Bulletins are available describing each of the following types.

McLeod Gauges: Extremely accurate mercury manometers; the standard for high-vacuum instrumentation calibration.

Pirani and Thermocouple Gauges: Many models available for measuring pressures in the 1 or 2 Torr to 10^{-3} Torr range.

Magnevac® Gauge: An ultra-stable thermal-conductivity gauge covering the atmosphere to $1x10^{-3}$ Torr range.

Cold Cathode Gauges: Often called Phillips or discharge gauges; they measure pressures as low as $1x10^{-7}$ Torr.

Hot Filament Gauges: These ionization gauges measure pressures from $2x10^{-9}$ Torr or lower to $1x10^{-3}$ Torr (or up to 2 Torr with accessory thermal circuits).

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Figure 27. Vacuum Gage Readout Meter With Specifications (CVC) (Sheet 6 of 6)

CIRCULAR CHEVRON CRYO-BAFFLES
NRC 0316-0-4, NRC 0316-0-6, NRC 0316-0-10

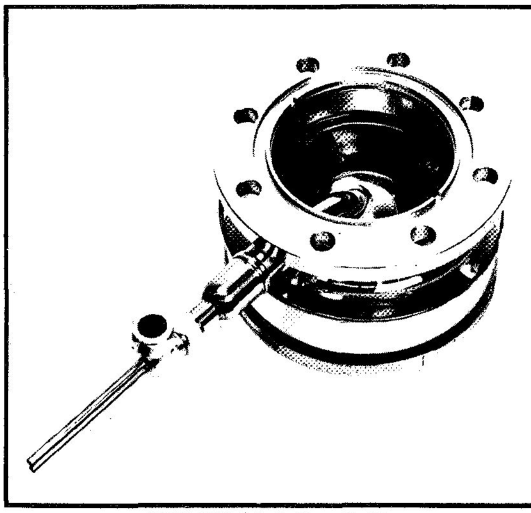
. . . for NRC VHS series pumps

GENERAL DESCRIPTION

Cryo-baffles for the 4″, 6″, and 10″ VHS pumps are specifically engineered to complement the performance of these very high speed diffusion pumps. When used with VHS pumps, NRC 0316 series cryo-baffles achieve the best liters/second/dollar performance attainable. A unique circular chevron geometry provides the maximum conductance possible for an optically dense baffle.

A new creep barrier and stainless steel, copper and nickel-plated construction promote clean system operation. Minimum use of internal welds reduces the possibility of leaks at cryogenic temperatures and at the same time reduces the possibility of contamination from outgassing. All welds are nickel-plated.

The NRC 0316 series cryo-baffles may be cooled by liquid nitrogen, water, or mechanical refrigeration. Filling is conveniently accomplished through the single pant-leg fill and vent assembly. Polished reservoir and facing surfaces of the chevron and outer shell result in extremely low emissivity and economy in use of refrigerants.



NRC 0316-0-4 Cryo-Baffle

FEATURES

- **High Conductance** . . . complements the performance of the VHS unit.

  Economy . . . with the VHS pump, an NRC 0316 series cryo-baffle provides the best liters/second/dollar performance obtainable.

  Cleaner System Operation . . . creep barrier effectively prevents back-migration of oil.

  Low Outgassing . . . stainless steel shell, reservoir flanges and welds are nickel plated. There is no exposed mild steel anywhere.

Convenience . . . unique fill and vent assembly uses single pant-leg design with positive bottoming of fill tube and alternative cooling methods.

Versatility . . . 0316 series cryo-baffles can use any level controller 0.225″ or less in diameter.

Long Holding Time . . . low emissivity and excellent economy in use of refrigerant are promoted by the polished reservoir and facing surfaces of the chevron and outer shell.

Fewest Internal Welds . . . reduces possibility of leaks developing when cryo-baffle is at cryogenic temperatures.

OPERATING SPECIFICATIONS

	NRC 0316-0-4	NRC 0316-0-6	NRC 0316-0-10
Conductance (Below 10^{-4} torr)	950 l/s	1800 l/s	4450 l/s
Reservoir volume	925 cc	1750 cc	5400 cc
Liquid nitrogen required to fill and cool initially (approx.)	3300 cc	3500 cc	9000 cc
Liquid nitrogen consumption rate at ultimate pressure (approx.)	220 cc/hr	350 cc/hr	900 cc/hr
Holding time for single liquid nitrogen charge (approx.)	4-1/2 hrs	5-1/2 hrs	6 hrs*

**Without using auxiliary water baffle*

Figure 28. Vacuum System Chevron Baffle With Specifications (NRC) (Sheet 1 of 2)

SPECIFICATIONS

	NRC VHS-4	NRC VHS-6	NRC VHS-10
Speed (max.): Air	1200 1/s	2400 1/s	5300 1/s
Helium	1500 1/s	3000 1/s	7020 1/s
Operating Range:	1 x 10^{-3} to extreme high vacuum	1 x 10^{-3} to extreme high vacuum	1 x 10^{-3} to extreme high vacuum
Typical Throughput at 10^{-2} torr:	2.5 torr 1/s (with 10 cfm backing pump)	4.0 torr 1/s (with 20 cfm backing pump)	8.0 torr 1/s (with 30 cfm backing pump)
Forepressure (max.):	6.5 x 10^{-1} torr (no load) 5.5 x 10^{-1} torr (at 2.0 torr 1/s)	6.5 x 10^{-1} torr (no load) 5.5 x 10^{-1} torr (at 2.5 torr 1/s)	6.5 x 10^{-1} torr (no load) 5.5 x 10^{-1} torr (at 5 torr 1/s)
Backstreaming (at pump inlet):	0.0005 (mg/cm^2/min)	0.0005 (mg/cm^2/min)	Less than 0.0007 (mg/cm^2/min)
Fluid Charge:	300 cc	500 cc	1000 cc
Heat-up:	10 min.	10 min.	17 min.
Cool-down:	10 min.	10 min.	10 min.
Water (min):	0.15 gpm @ 60-85°F	0.25 gpm @ 60-85°F	0.4 gpm @ 60-85°F
Heater Rating:	1400 watts (120/240/ 1/60)±5%	2200 watts (120/240/ 1/60) ±5%	5000 watts (240/480/ 3/60) ±5%
Height:	18″	21-1/2″	30-3/4″
Inlet:	5-3/4″	7-3/4″	12″
Vertical Clearance Required for Heater Replacement:	1-3/4″	1-3/4″	1-3/4″
Jet Assembly:	4-stage self aligning	4-stage self aligning	4-stage self aligning
Foreline Baffle:	Stacked half-moon	Stacked half-moon	Stacked half-moon
Water Connections:	1/8″ FPT	1/8″ FPT	1/4″ FPT
Materials of Construction:			
Body:	Stainless Steel	Stainless Steel	Stainless Steel
Flanges:	Stainless Steel	Stainless Steel	Stainless Steel
Fractionating Jet:	Stainless Steel	Stainless Steel	Aluminum
Foreline Baffle:	Stainless Steel	Stainless Steel	Stainless Steel
Cooling Coils:	Copper (silver-soldered)	Copper (silver-soldered)	Copper (silver-soldered)
Reflector:	Aluminum	Aluminum	Aluminum
Net Weight:	27 lbs.	45 lbs.	120 lbs.
Shipping Weight:	55 lbs.	75 lbs.	150 lbs.

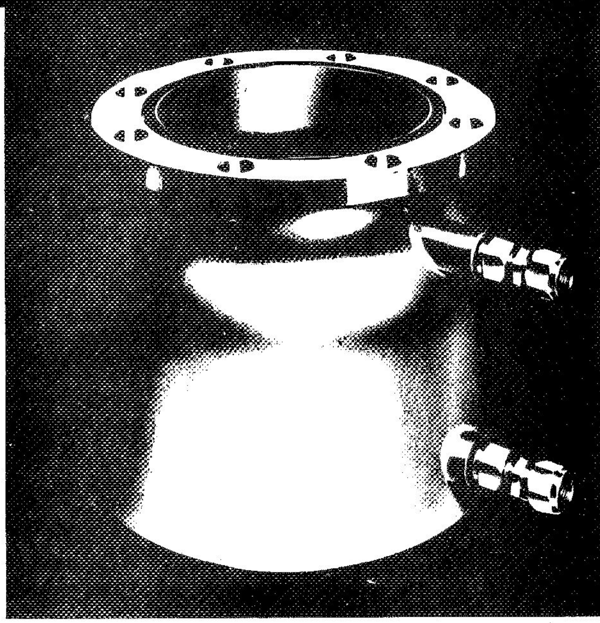
Figure 28. Vacuum System Chevron Baffle With Specifications (NRC) (Sheet 2 of 2)

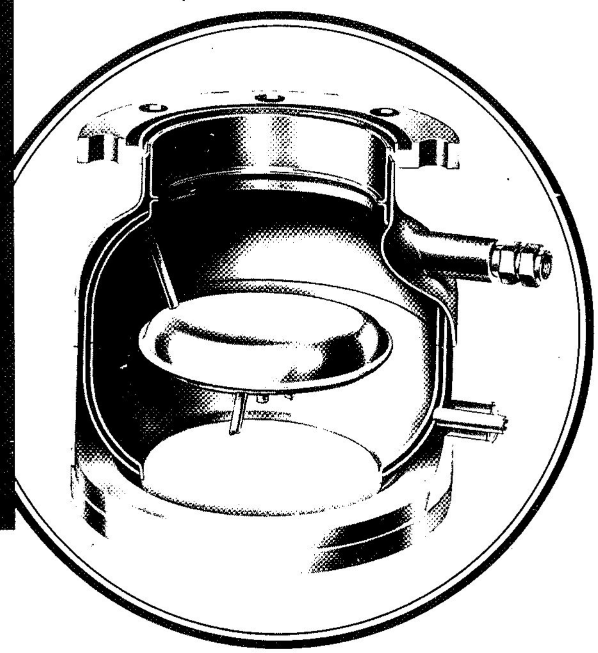
![Kinney]

CATALOG BULLETIN
3501.1
PAGE 1

DUAL-COOLANT DRUM BAFFLE

SERIES KDB





2", 4", 6" and 10" Sizes
Dual-Coolant Type

GENERAL DESCRIPTION

KINNEY KDB Series Dual-Coolant Baffles are expressly engineered for systems and conditions where low ultimate pressures and elimination of backstreaming dictate the need for more effective baffling than can be obtained with conventional water or Freon cooled baffles. Additionally, when used with liquid nitrogen, coolant surfaces are so arranged that KDB Baffles become an effective pump for condensable gases.

The KDB design provides a nickel plated steel casing furnished with standard A.S.A. flanges top and bottom . . . the top flange is O-ring grooved. Within the casing, a stainless steel coolant drum, which acts as a baffle, is connected by tubes to a stainless steel outer storage wall. Stainless steel inlet and outlet thermal tubes, having O-ring sealed union connections, are attached to the storage wall.

When used with liquid nitrogen as a coolant, it is recommended that an external liquid nitrogen storage reservoir be used. Both reservoirs and automatic level controllers may be provided at the time of purchase or they may be purchased separately.

When water is used as a coolant, the water should be at least 2° C. below ambient, using the lower connection for the inlet and the upper one for connecting to the drain line.

Features

Uses liquid nitrogen or water as coolant

•

Stainless steel drum and storage wall construction

•

Improved conductance and trouble-free performance

•

Optically dense

•

Bakeable

•

Anti-Creep

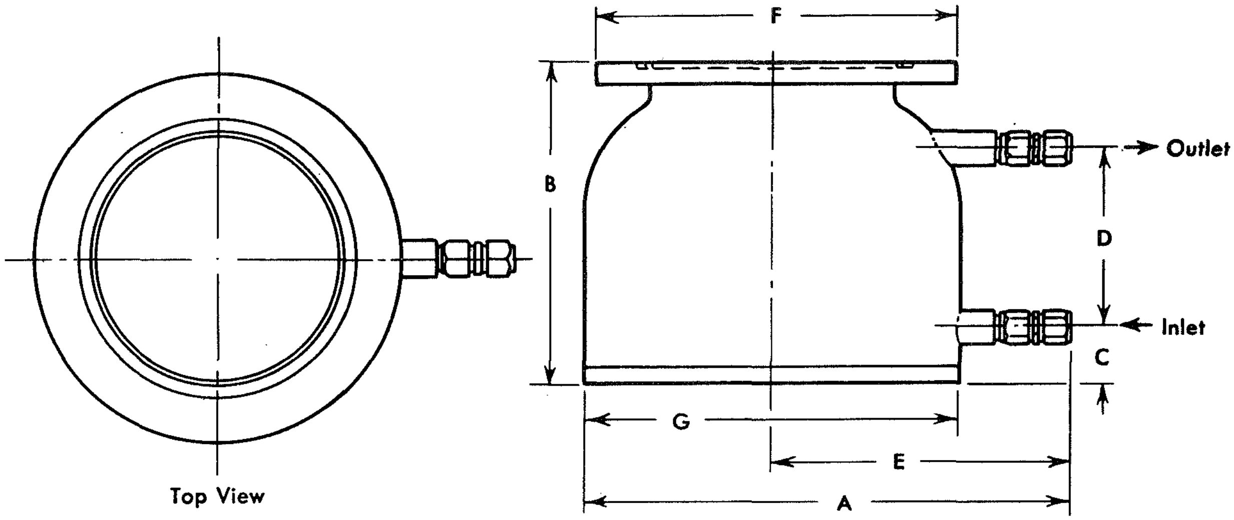
•

150 lb. A.S.A. flanges . . . furnished with JAN O-rings

Figure 29. Vacuum System Drum Baffle With Specifications (Kinney) (Sheet 1 of 2)

All cold surfaces in contact with the vacuum are directly cooled by the coolant used. There are no temperature gradients due to heat conductance along baffle plates.

In the pressure region where the mean free path is greater than the characteristic trap dimensions, the trap is a minimum one bounce (on cooled surface) baffle. The average number of bounces is in excess of six which is greater than that of other baffle configurations.



SPECIFICATIONS

MODEL No.							TOP FLANGE							BOTTOM FLANGE					LIQUID NITROGEN			
	Item No.	A	B	C	D	E	O.D.	I.D.	Thickness	B.C.	No. Holes	Dia. of Holes	O-Ring Size	O.D.	I.D.	B.C.	No. Holes	Size of Holes	Weight (lbs.)	Capacity (Liters)	Consumption (Liters per Hour)	Req'd to Stabilize (Liters)
KDB-2																						
KDB-4	026502	12¾"	7¾"	1⅝"	3⅞"	8¼"	9"	5¼"	9/16"	7½"	8	¾"	050435	9"	5¼"	7½"	8	⅝-11	25	0.6	0.5	2.0
KDB-6	026503	14¾"	9½"	1¾"	5¼"	9¼"	11"	7"	11/16"	9½"	8	⅞"	050443	11"	7⅛"	9½"	8	¾-10	40	1.7	0.6	3.0
KDB-10																						

Flange drillings conform to 150 lb. ASA Standards.
All bolt holes straddle centerlines.
O-Ring sealed coolant fitting accepts ½" O.D. tubing.

ACCESSORIES

A radiation shield may be attached to the bottom of the coolant drum to reduce the refrigeration load due to radiated heat from the diffusion pump jet structure.

KINNEY Liquid nitrogen Reservoirs with capacities for all KINNEY KDB Drum Baffles are available (see Catalog Bulletin 3960.1).

KINNEY Level Controllers for use with liquid nitrogen coolants are available (see Catalog Bulletin 3915.1).

KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY
3529 WASHINGTON STREET · BOSTON 30 · MASS.

Figure 29. Vacuum System Drum Baffle With Specifications (Kinney) (Sheet 2 of 2)

BULLETIN 10-13

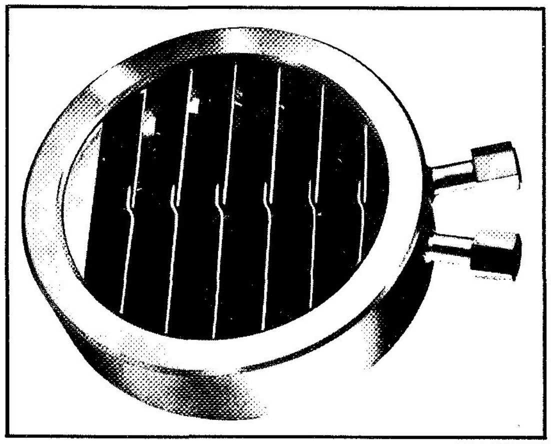
CHEVRON-RING BAFFLES, type BCRU and BCR

CVC

ULTRA-HIGH-VACUUM TYPE (BCRU)

FEATURES

- **Stainless Steel Ring With Nickel-Plated Copper Chevrons . . . Minimal Outgassing**
- **High Conductance**
- **Water-Cooled Chevrons And Ring Reduce Oil Creep**
- **Metal Gaskets Provide Leak-Tight Seals in Installations Which Require Bake-Out**
- **Simple to Install . . . Fit Inside Bolt Circle of Standard Flanges of the Same Nominal Size**



Designed primarily for ultra-high-vacuum applications, the BCRU type chevron-ring baffles are also useful in high-vacuum systems which require a water-cooled baffle. Each baffle consists of a hollow stainless steel ring with brazed-in chevrons of nickel-plated copper. These materials were chosen to provide MINIMAL OUTGASSING in applications which require bake-out at high temperatures. Water inlet and drain connections are FPT fittings.

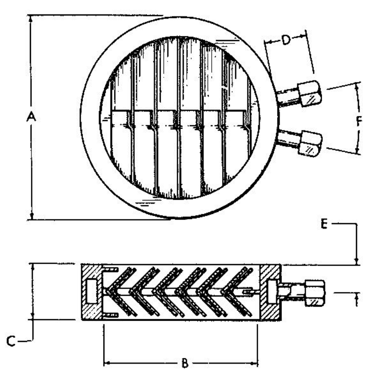
The upper and lower surfaces of the stainless steel ring have the extremely smooth finish required to provide LEAK-TIGHT SEALS when used with metal gaskets in applications which require bake-out. Con-O-Ring gaskets can be used if bake-out is not needed. Two aluminum gaskets, which withstand bake-out to 300°C, are supplied with each baffle. CVC stocks gold gaskets for bake-out to 500°C.

HIGH CONDUCTANCE of the BCRU baffles results from the short flange-to-flange distances, large inner diameters, and the most favorable balance between optimum conductance and baffle efficiency.

The BCRU type baffles have no flanges. These baffles fit inside the bolt circle of standard flanges of the same nominal size.

TYPE BCRU BAFFLE DIMENSIONS

Nominal Size	Type No.	A	B	C	D	E	F	Cooling Connections	Gasket Surface Width	Shipping Weight
2"	BCRU-20	2 31/32"	2 5/16"	1 3/8"	1 1/16"	11/16"	30°	1/8" FPT	13/64"	5 lb.
4"	BCRU-40	6 13/16"	5 7/16"	1 7/8"	1 17/32"	15/16"	22°	1/4" FPT	9/16"	14 lb.
6"	BCRU-60	8 11/16"	7 3/16"	1 7/8"	1 17/32"	15/16"	22°	1/4" FPT	9/16"	21 lb.
10"	BCRU-100	13 1/4"	11 1/2"	2 7/8"	1 17/32"	1 7/16"	12°	1/4" FPT	11/16"	37 lb.



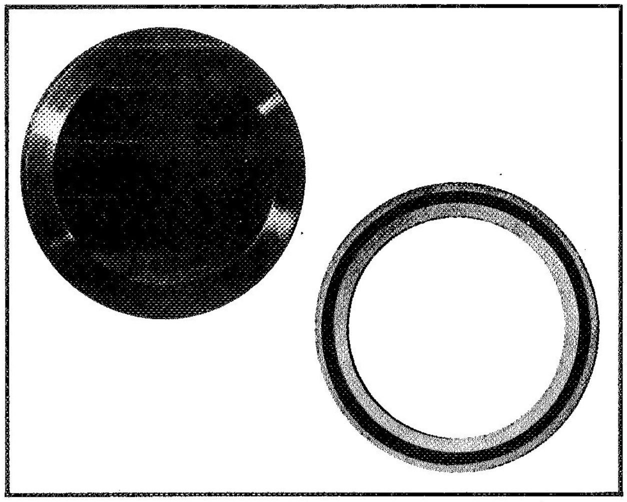
Consolidated Vacuum Corporation

Figure 30. Vacuum System Chevron Baffle With Specifications (CVC) (Sheet 1 of 2)

HIGH-VACUUM TYPE (BCR)

FEATURES

- **Reduce Backstreaming Without Auxiliary Cooling**
- **High Conductance**
- **Smooth Interior Surface Reduces Oil Creep**
- **Fit Inside Bolt Circle of Standard Flanges of the Same Nominal Size**



The BCR type baffles, like all other CVC chevron baffles, feature HIGH CONDUCTANCE. Short flange-to-flange distances, large inner diameters, and chevrons which provide the best balance between optimum conductance and baffle efficiency all contribute to this high conductance.

BCR baffles are one-piece aluminum castings with SMOOTH INTERIOR SURFACES to reduce creep and assure proper drainage of condensed pump fluid. There are no connecting flanges or bolt holes; the baffle is easily installed inside the ring of bolt holes on a standard flange of the same nominal size. Gasket grooves, which can trap atmospheric gases and release them into the vacuum system, have been eliminated. Flat machined surfaces insure leak-tight seals with Con-O-Ring gaskets, standard Buna-N O-rings in aluminum ring retainers. Con-O-Rings not only position the gasket on the seating surface, but also limit the compression of the O-ring in accordance with good vacuum practice. One Con-O-Ring is supplied with each baffle.

BCR baffles are designed for installation directly above a diffusion pump and are cooled by conduction from the water-cooled pump flange. NO AUXILIARY COOLING is required.

TYPE BCR BAFFLE DIMENSIONS

NOMINAL SIZE	TYPE	O.D.	I.D.	THICKNESS*	SHIPPING WEIGHT
2"	BCR-21A	$2\frac{31}{32}$"	$2\frac{1}{4}$"	$1\frac{1}{4}$"	2 lb.
4"	BCR-41A	$6\frac{13}{16}$"	$5\frac{1}{4}$"	$1\frac{7}{8}$"	9 lb.
6"	BCR-61A	$8\frac{11}{16}$"	7"	$1\frac{7}{8}$"	12 lb.
10"	BCR-101A	$13\frac{1}{4}$"	$11\frac{1}{4}$"	$2\frac{3}{4}$"	30 lb.

CVC *Consolidated Vacuum Corporation*

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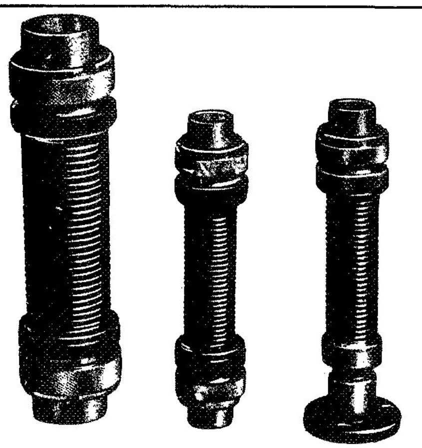
Figure 30. Vacuum System Chevron Baffle With Specifications (CVC) (Sheet 2 of 2)

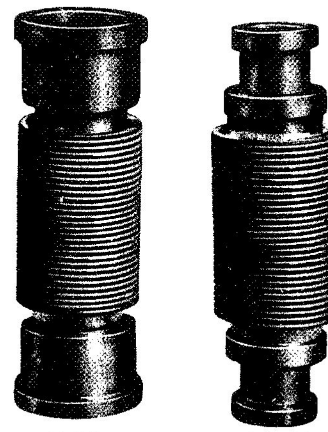
Flexible Vacuum Connexions

Metal Bellows

Where vibration or slight movement is possible between one part of a vacuum system and another, such as at the rotary pump connexion, a leak-tight flexible bellows can be fitted.



C3605 C3402 A8402



C6601 C6501

Bronze bellows with two vacuum unions

Description	Code	Price
½ in (12.7 mm) bore bellows 2½ in (63.5 mm) long with two ½ in unions for 0.596 in (15 mm) o.d. tube.	C3402	
¾ in (19 mm) bore bellows 2⅝ in (66.68 mm) long with two ¾ in unions for 0.846 in (21.5 mm) o.d. tube.	C3502	
1 in (25.4 mm) bore bellows 3½ in (88.9 mm) long, with two 1 in unions for 1.112 in (28.2 mm) o.d. tube.	C3605	

Bronze bellows with one vacuum union and one flange

The ½ in bellows is suitable for direct attachment to the rotary pumps quoted.

Description	Code	Price
½ in (12.7 mm) bore bellows 2⅝ in (67 mm) long with flange to suit 1SP20, 2SC20A, 1SC30A series pump inlets and one ½ in union.	A8402	
¾ in (19 mm) bore bellows 2⅝ in (66.68 mm) long with one ¾ in union to take 0.846 in (21.5 mm) o.d. tube and one ¾ in bore grooved flange with 4 holes 0.157 in (4 mm) dia. on $1\frac{5}{16}$ in (33.34 mm) PCD and 'O' ring, four 4BA socket head fixing screws× ⅝ in (15.9 mm) long and W3 hexagon wrench.	C3503	
¾ in plain mating flange to suit ¾ in grooved flange.	C370-2	

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Figure 31. Vacuum System Vibration Eliminators With Specifications (Edwards) (Sheet 1 of 2)

Bronze bellows with two union tailpieces only

These bellows as listed are received directly by the rotary pumps quoted. In order to make up a complete union end, a union body, nut and 'O' ring are required for each end and are available separately.

Description	Code	Price
1½ in (38.1 mm) bore bellows 3½ in (88.9 mm) long, with two 1½ in, union tailpieces. For direct fitment to 1SC450 pumps.	C4902	
Mating components for C4902		
1½ in union body to take 1.612 in (40.8 mm) o.d. tube.	C360-11	
1½ in union nut.	C360-30	
'O' ring	VOR1146	
2 in (50.8 mm) bore bellows 3½ in (88.9 mm) long, with two 2 in union tailpieces. For direct fitment to 1SC1500, 3000 pumps.	C5102	
Mating components for C5102		
2 in union body to take 2.128 in (54.2 mm) o.d. tube.	C3604-1	
2 in union nut	C3604-6	
'O' ring	VOR1159	

Stainless steel bellows with ends for Edwards solderless pipeline coupling system. These bellows require coupling system components for joining to system.

Description	Code	Price
½ in (12.7 mm) bore by 5 in (127 mm) long bellows with ½ in coupling connexions at each end.	C6501	
1 in (25.4 mm) bore by 5 in (127 mm) long, bellows with 1 in coupling connexions at each end.	C6601	

Vacuum Tubing and Hose

Nitrile Rubber Vacuum Tubing

Code	Description	Bore mm	o.d. mm	per ft	per cm	Price
H210/1	Available in continuous lengths but it is recommended that tubing for vacuum use should not exceed 3 ft (0.9 m)	4	14	1	30.5	
H210/2		5	19	1	30.5	
H210/3		7	17	1	30.5	
H210/4	Available only in 3 ft (0.9 m) lengths	9	25	3	91.4	
H210/5		12	28	3	91.4	
H210/6		20	34	3	91.4	

Neoprene Flexible Hose

Code	Description	per ft	per cm	Price
C660-25	With steel reinforcing spring. Available in 1 ft (30.5 cm) lengths. To suit 1⅛ in (28.58 mm) o.d. tube	1	30.5	

To meet administrative requirements there is a £3.0s.0d. minimum order charge.

Edwards research leads to continuous improvement; details of products supplied may therefore vary from those described.

EDWARDS HIGH VACUUM INC.
A member of Edwards International Group
3279, GRAND ISLAND BOULEVARD
GRAND ISLAND, NEW YORK.
Telephone: Grand Island RR3-7553 Telex: 710-260-1350 Edhivac Gett

Printed in England

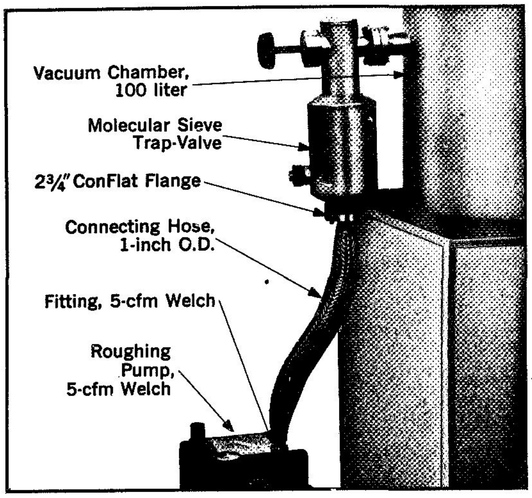
08710-2

Figure 31. Vacuum System Vibration Eliminators With Specifications (Edwards) (Sheet 2 of 2)

Cut Roughing Time, Improve Performance...
Stainless Steel Connecting Hoses Upgrade
Your Vacuum System.

STAINLESS STEEL CONNECTING HOSES

Data Sheet



APPLICATIONS

Varian's stainless steel connecting hoses are used primarily to join a mechanical roughing pump to a vacuum system with maximum efficiency. They also serve as "jumper" lines between system chambers, "cold-fingers" to chill large chambers, and can be shaped to form foreline traps. They may be used at temperatures ranging from —196°C to 400°C.

DESCRIPTION

These all-stainless steel hoses, 18 inches long, consist of a thin-walled bellows covered with flexible braid for extra strength and protection. Made in 1-inch and 1½-inch sizes, they are provided with rotatable 2¾-inch O.D. ConFlat® Flanges for reliable vacuum connections. The 1½-inch hose is available in two models: one with ConFlat Flanges on both ends, the other with one ConFlat Flange and a fitting that mates with the Welch 15 cfm mechanical pump. The 1-inch hose has one ConFlat Flange and a fitting that mates with the Welch 5 cfm pump.

ADVANTAGES

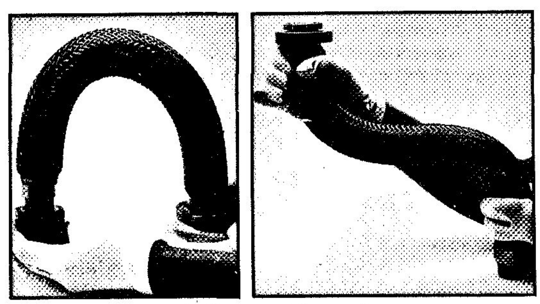
Faster Pumping. The inherent cleanliness or stainless steel plus the greater conductivity of the hose design (the internal reinforcing structure needed in rubber and Tygon hoses is absent) contribute to improving pumping speed as indicated in the performance curves shown. The lower outgassing rate of stainless steel also ensures more rapid leak detection when the hose is used to make a connection with a leak detector.

Lower Pressures. Systems can reach lower pressures than with rubber or Tygon hoses as indicated in the performance curves.

Bakeable. Stainless steel withstands high temperatures. Thus, these hoses remain coupled directly to chambers even during bakeout at 400°C.

Greater Flexibility and Protection. The flexible bellows construction means ease of use. The stainless steel braiding protects against over-extension and shields against damage while the bellows is under vacuum.

Reduced Vibrations. Stainless steel hoses dampen vibrations during rough-pumping better than rubber hoses and remain vibration-free when used as "jumper" lines.

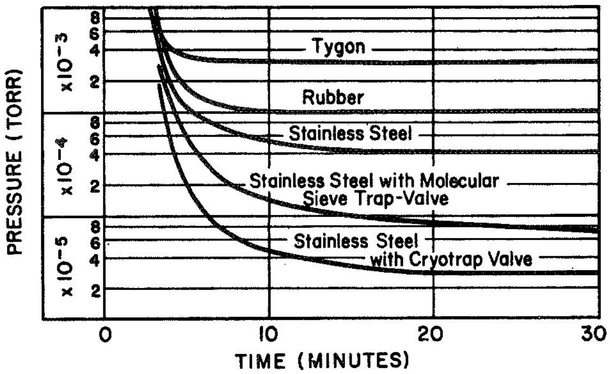


Flexibility and Strength

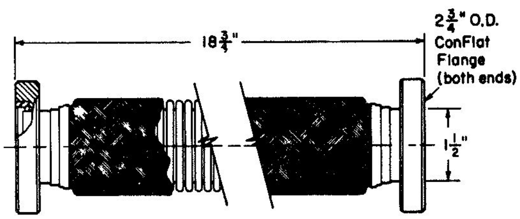
varian
vacuum division
611 hansen way/palo alto, california 94303

European inquiries:
VARIAN A.G.,
Baarerstrasse 77, Zug, Switzerland

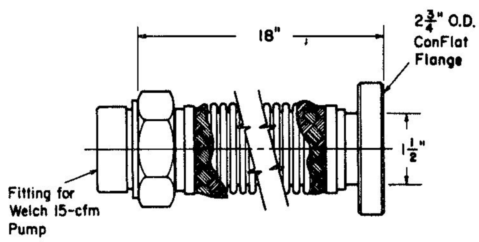
Figure 32. Vacuum System Vibration Eliminators With Specifications (Varian) (Sheet 1 of 2)



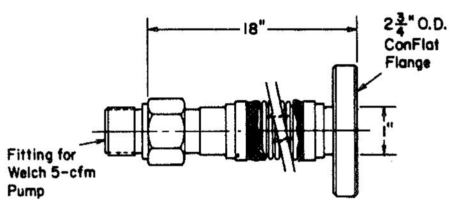
Data obtained with 15-cfm Welch Pump, 1½-inch hose 18 inches long, and 100-liter chamber. Pressure measured with MilliTorr* gauge mounted on system.



Model No. 952-5060



Model No. 952-5061



Model No. 952-5062

SPECIFICATIONS

Vacuum Range......No leaks detectable on a helium mass spectrometer with minimum sensitivity of 2 x 10^{-10} std. cc/sec.
Hoses with pump-fittings: to 10^{-6} Torr.
Hoses with 2 ConFlat Flanges: to 10^{-11} Torr

Pressure Range......50 psi maximum

Temperature Range......—196°C to +400°C.

Conductance......1-inch Hose: 4.3 liters/sec.
1½-inch Hose: 15 liters/sec.

Dimensions......1-inch Hose:
Bellows Neck O.D.: 1 inch
Bellows Thickness: 0.006 inch
1½-inch Hose:
Bellows Neck O.D.: 1½ inches
Bellows Thickness: 0.008 inch

Materials

Bellows Hose......321 Stainless steel

ConFlat Flanges, Welch Pump Fittings, and External Braid } 304 Stainless steel

ORDERING INFORMATION

DESCRIPTION	MODEL NUMBER	SHIPPING WT. Lbs.	Kg.
1½" Hose with ConFlat Flanges on both ends	952-5060	4	1.8
1½" Hose with ConFlat Flange and Welch 15-cfm Fitting	952-5061	2½	1.1
1" Hose with ConFlat Flange and Welch 5-cfm Fitting	952-5062	2	0.9
Mating ConFlat Flange (rotatable) 2¾" O.D. x 1½" I.D.	954-5071	½	0.2
Mating ConFlat Flange (rotatable) 2¾" O.D. x 1" I.D.	954-5073	½	0.2
Copper Gaskets for Flange (pkg/10)	953-5014	½	0.2
Screw, Nut, and Washer Set (pkg/25 sets)	953-5020	1½	0.7

Flange gaskets and screw-and-nut sets must be ordered separately.

HOW TO ORDER

Address orders or requests for additional information to the nearest Varian District Office or to Varian Associates, Vacuum Division, 611 Hansen Way, Palo Alto, California 94303. European orders should be addressed to Varian A.G., Baarerstrasse 77, Zug, Switzerland. Order all products by name and model number.

*Trademark

Figure 32. Vacuum System Vibration Eliminators With Specifications (Varian) (Sheet 2 of 2)

VAC-2217B (Printed in U.S.A. 10M1067) Section 6

Isolation valves are made by a number of manufacturers and a representative's description is provided in pages 48 through 57. Either pneumatically or solenoid operated valves would be applicable in a central drawdown system. However, the electrically operated valves would require a lesser number of total components increasing system reliability. Costs run from \$20.00 to \$250.00 per valve.

A number of companies manufacture conventional vacuum pump-down stations with various degrees of automation. Varian produces a fully automated single push button station with a two (2) inch diffusion pump. This station automatically cycles through rough pump, diffusion pump warm up and high vacuum pumping with the diffusion pump. A unit of this type costs approximately \$3200 with increased cost as pump size increases.

Baffles are normally considered part of the pumpdown station. In an application at Cape Kennedy such a baffle should be of the water cooled type to preclude the need for liquid nitrogen, particularly for a multistation system.

Devices for remote indication of vacuum levels are available (See pages 59 through 67). These devices would be incorporated into the tower logic to indicate a "go - no-go" system for propellant loading. It is envisioned that thermocouple probes would be used as sensing elements. Component selection would be in part based on the results of the study conducted in detail during the Vacuum Jacketed Umbilical Lines Advancement Study.

In conclusion, there are a number of manufacturers of high quality vacuum stations and components. A partial catalog listing has been included in this report indicative of these products, but not including all possible sources due to the amount of material. Vacuum ion pumps may be of value in a central pumpdown system but further evaluation would have to be made under test conditions. All companies visited were cooperative and helpful in regards to their products and limitations. No single vacuum station is now manufactured that would meet all the requirements of an installation at Complex 39, but several companies by relatively simple modifications could meet these requirements. Where feasible, component selection would be made based on the results of study during other phases of this program, relating to seal off valves, vacuum probes, flexible lines, etc.

6.3 DESIGN PHASE

6.3.1 Design Evaluations

The design phase progressed from system concepts and their acceptability for application at Complex 39, Cape Kennedy, to more detailed requirements and analysis after selection of the more desirable system. During the design phase, an analysis was made of parallel and series connected systems on individual swing arms. For the evaluation, it must be kept in mind that a separate system is intended for both the liquid hydrogen and liquid oxygen line segments from the standpoint of safety or catastrophic failures.

Four (4) systems were considered during the conceptual part of the design phase. These were as follows:

A. Single station system with conventional vacuum pumps.

B. Multistation system with conventional vacuum pumps.

C. Vacuum ion pumps integral to each line segment.

D. Ion/Absorption pump combination.

The single station system, as the name implies, would be a single pumping station located at some convenient site on the umbilical tower connected to all swing arm line segments. Such a pumping station would be automated to reduce human error and instrumented to allow monitoring of the various line segment annulus pressures. A system of isolation valves would allow pumping of any or all line segments as required.

The station would consist of a conventional diffusion pump with its attendant roughing and/or foreline mechanical pump. (See Figures 4 and 5.) Considerations for a single system are:

Advantages	Disadvantages
1. Less functional hardware compared to a multi-station. 2. Less Costly. 3. Lower maintenance.	1. Larger pumps required. 2. Complex manifold installation. 3. Longer pumpdown time, due to lower conductance (from analysis).

The multistation system is of the same basic concept as the single station system except a pumping station would be located at each swing arm level having vacuum jacketed propellant lines. (See Figures 4 and 5.) Considerations for a multistation system are:

Advantages	Disadvantages
1. Smaller pumps. 2. No large size manifold compared to single stations. 3. Easier capabilities for leak checking line segments. 4. Pumpdown time quicker	1. More costly for functional equipment. 2. More maintenance. 3. More functioning hardware than single system.

In the vacuum ion pump concept, line segments would be provided with individual ion pumps. No control system, as such, would be needed except for a power supply located at each swing arm level. Pumping would be on a continuous basis maintaining a high vacuum in the annulus of each line segment to prolong pump life. If pumps could maintain a vacuum of 1×10^{-6} sec/cc of Hg, a life expectancy of from three (3) to five (5) years could be expected. (See Figure 33.) Considerations for such a system are:

Advantages	Disadvantages
1. Less maintenance 2. No external hardware such as manifold. 3. No thermocouples required as pump will indicate pressure. 4. Pump integral with line segment.	1. System must be evaluated for feasibility. 2. Low pump life at higher pressures. 3. Continual power supply required. 4. Lines must be pre-conditioned.

The last concept considered was an ion/absorption pump combination, in which larger ion pumps would be used at each swing arm level in conjunction with an absorption pump for initial pumpdown. Under these conditions, pumping would not be continuous as with the conventional systems, but on an "as needed" basis. (See Figure 34.) Systems considerations are:

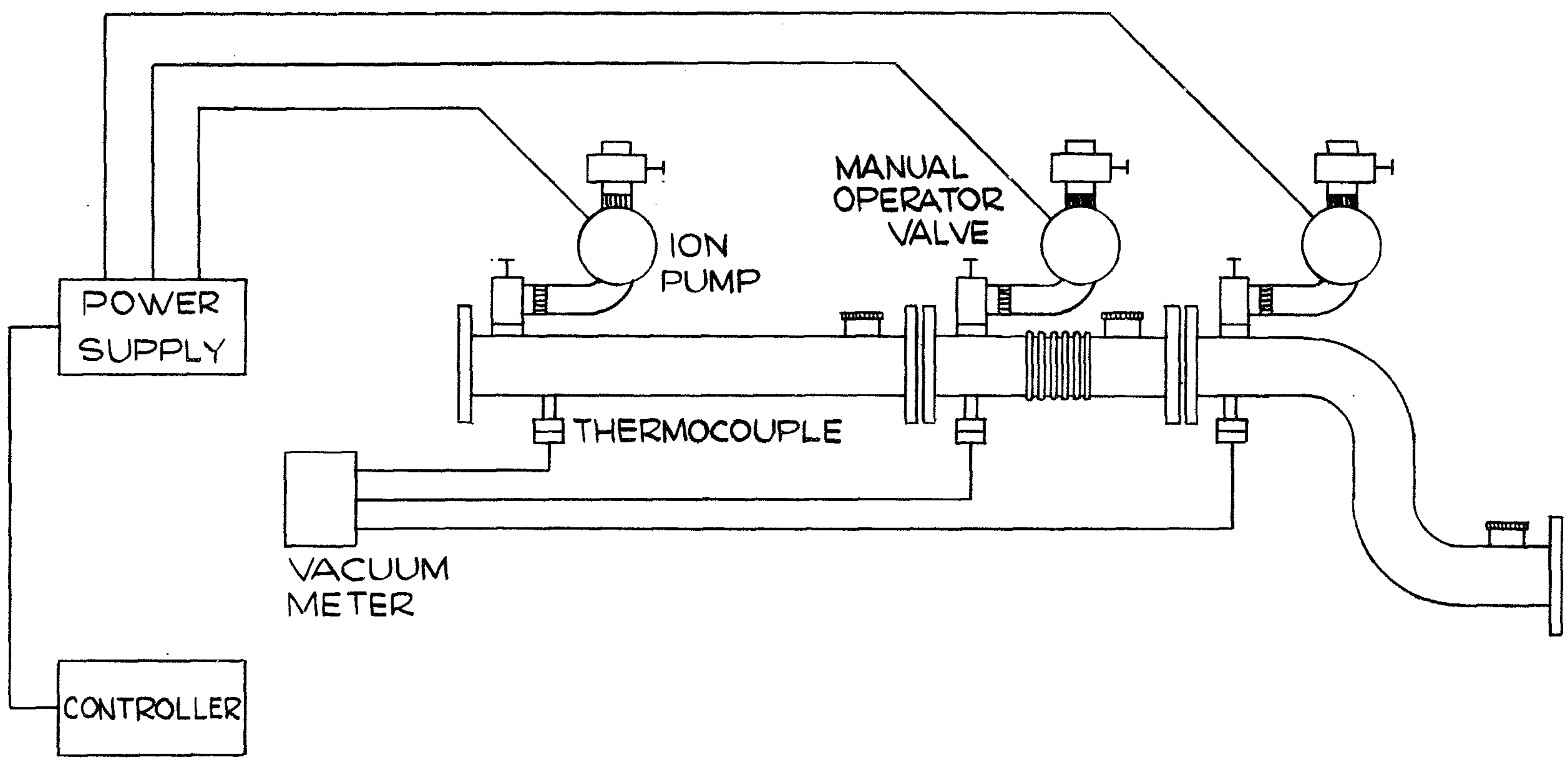


Figure 33. Vacuum Ion Pump System

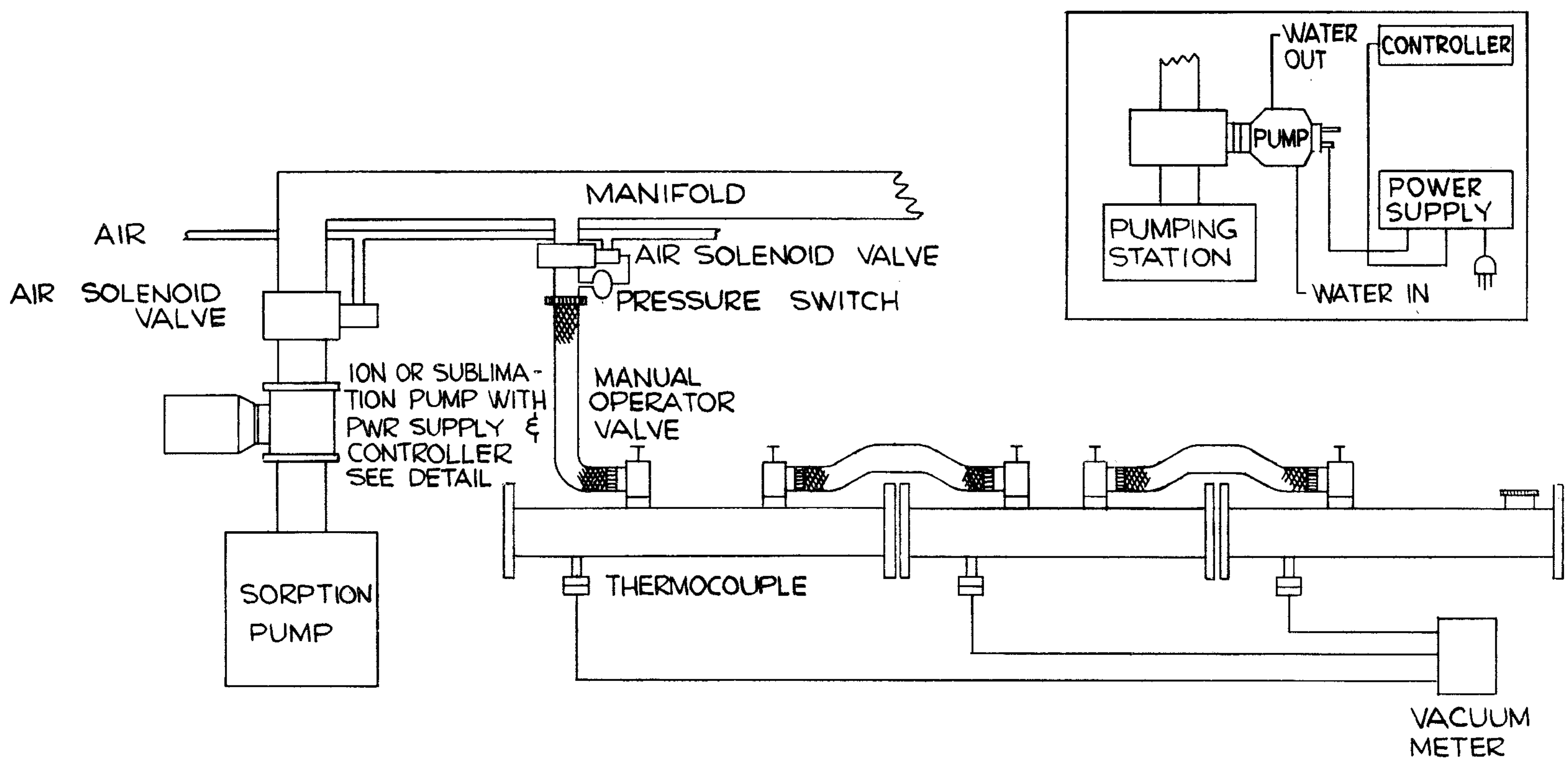


Figure 34. Sorption/Ion Pump Combination Series System

Advantages	Disadvantages
1. System relatively light and small.	1. System would need evaluation for feasibility.
2. No thermocouples needed.	2. Liquid nitrogen required on tower.
3. Ion pump functions as leak detector.	3. Conductance of manifold critical to efficient ion pump operation.

Detailed analysis found in Paragraph 6.3.2 of this report shows that the multistation system is more feasible than the single station system when comparison is made of the required pump-down time and manifold line size. See summary on Pages 91 and 92. Analysis of the swing arm lines show that manifold size is critical to the time for pumpdown of the most remote line from the vacuum station. Because of this, the multistation system was selected as the most promising of the two systems to perform the function of repumping a line to a vacuum level meeting the capacity of the gettering material to cryopump the line segment annulus to 0.1 micron or better.

Analysis of ion pump integral with the line segment, indicates a pump on the order of several liters/second would facilitate maintaining the vacuum level in a preconditioned line. However, conductance and space relationship is very critical for efficient operation of ion pump. Further evaluation would be required to determine the real possibility of such an application. Ion pumps are used presently on cryogenic dewars to maintain the annulus at a high vacuum. Varian has applied such an appendage pump on the life support cryogen bottle on Apollo.

The last system, the ion/absorption pump system, while worth consideration, contains the faults of a more conventional system with an untried application of state-of-the-art hardware. The liquid nitrogen requirement requires additional facilities and possible plumbing at the Complex. For these reasons, this concept was dropped.

After selection of the multistation system as the most feasible with the integral ion pump as system worth evaluation, a detail design requirement was made of the two (2) systems.

For the multistation system, the first consideration was the comparison of the swing arm lines consisted in parallel versus a series connection. While analysis shows a series connected line to be as efficient as a parallel connected system, leakage or failure of a line in a series system would prevent pumping of any downstream line from the pump. Based on this, a selection of the parallel concept was made. Figure 5 depicts a parallel manifold system.

The multistation system will consist of an automated pumpdown station with a two (2) inch diffusion pump and 5 CFM mechanical pump. The unit will be enclosed in a weather proof housing. A water cooled baffle will be used to prevent back streaming of oil into the manifold system. Wherever possible, construction would be of corrosion resistant steel. Pressure and temperature sensors will be employed to control its automatic sequence of operation of pumping station. Located at the station will be the line segment monitoring panel. This panel will contain the vacuum probe meters and controls for opening and closing the isolation valves.

During the operation, the manifold will be pumped down by either the mechanical pump or diffusion pump, depending on the pressure of annulus of the line to be pumped. When the manifold is at the same pressure or slightly below the pressure of the line segment to be pumped, the isolation valve will be opened and the line segment pumped until a stable static pressure can be maintained. Provisions will be made at its pumping station for connecting a helium mass spectrometer for leak testing of line segments.

The vacuum probe units will be similar to the CVC Sensuvac controller. (See Page 64 .) This unit will allow the system to be connected to the tower block logic allowing monitoring at the launch control consoles on a "go - no-go" basis, indicating the status of each propellant line prior to prepellant loading.

Any power failure or increase in pressure above 2000 microns in the manifold will automatically cause all isolation valves to close. The manual switch for each isolation valve shall be capable of overriding this automatic shutdown feature.

The isolation valves shall be constructed of stainless steel (Series 316) and shall operate upon a 28 volts DC applied to the solenoid. The isolation valve will be located on the line segment with provisions for replacing the entire valve or the valve seats. The valves will be of the high conductance type with a 1.5 inch opening. This valve will be coupled to the swing arm manifold through a flexible hose.

All manifold components will be constructed of Series 316 stainless steel. The flexible couplings will be kept as short as possible and still allow the normal operation of the swing arm propellant lines during propellant loading and launch. The

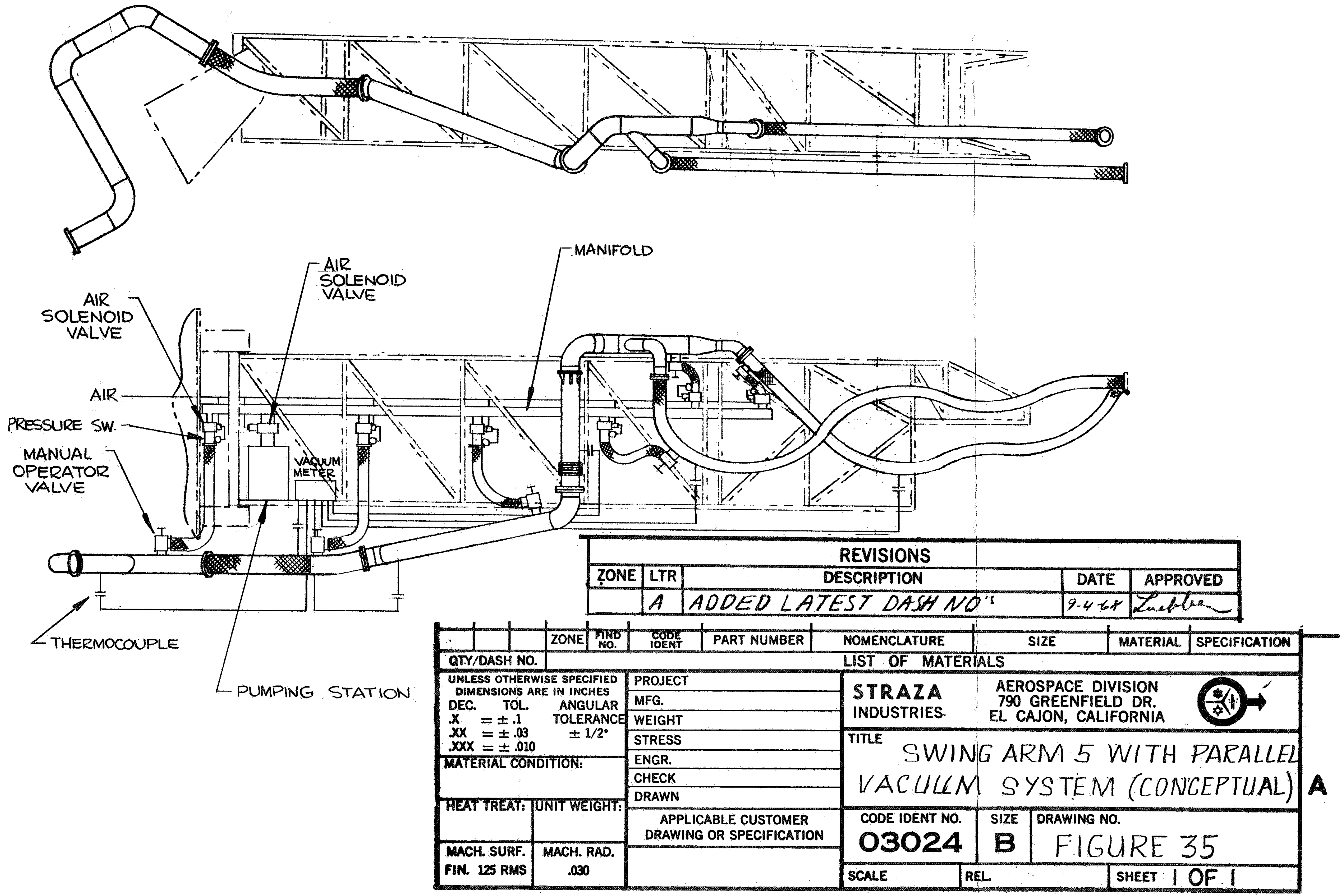


Figure 35. Swing Arm 5 With Parallel Vacuum System (Conceptual)

swing arm manifold will be a 2.5 inch diameter hard line constructed of 316 Series stainless steel. Design of the manifold will be such to minimize the number of levels required to reach the pumping station.

Analysis shows that a one (1) liter/second vacuum ion pump would be adequate for maintaining pressure in a propellant swing arm line. However, due to the lines configuration and consequently its effect on conductance, two one (1) liter/sec vacuum ion pumps located at each end of the line should be employed. The body of the vacuum ion pumps would be constructed of Series 316 stainless steel with an isolation valve between the pump and the vacuum annulus of the propellant line. A single high voltage power supply would be adequate to activate all the ion pumps located on a single swing arm.

Electrical connection would be of the water proof and explosion proof type.

6.3.2 Quality Assurance Program

To insure uniform standards of the central vacuum drawdown system, each component will be checked for physical dimensions and as required function acceptability. Acceptance tests will be run to confirm conformance of each component to the requirements of leakage and performance. During Phase II testing, Quality Assurance personnel will witness all tests.

Acceptance tests will be conducted on each component as well as a systems acceptance test. Quality Control will maintain records significant to potential failures in design to allow analysis for corrective action.

After establishment of system criteria, a procurement specification document will be prepared and reviewed by the AMETEK/Straza Quality Control Department for conformance to accepted manufacturing criteria. The Quality Control Department will review selected companies for their ability to conform to design specification before release of any purchase order for system procurement.

6.3.3 Reliability

Based on the criteria found in Paragraph 6.1.4 of this report, a preliminary reliability goal of 0.9494 has been established for the central drawdown system. This reliability number is based on the equation:

R (Sys) = R (Flex Hose) X R (Seal-off Valve) X R (Vacuum Probes) X r (Pump Station)

Where:

R (Flex Hose)	=	0.9900
R (Seal Off Valve)	=	0.9953
R (Vacuum Probe)	=	0.9644
R (Pump Station)	=	0.9991

The reliability number for the pump station was arrived at by removing the belt drive and replacing it with a direct drive system. Also the heating element would be designed very conservatively for long life.

The established reliability goal by its very nature includes part of the reliability goal established during other portions of the Phase I study program, such as seal off valves, etc.

6.3.4 Recommendations

Based on the results of the Phase II test program in relation to improved reliability of seal off valves, vacuum probes, and flexible propellant lines, a review of the central system concept should be made. Improved reliability of the subcomponents of such a system makes it more attractive for serious consideration as a means for simplifying repumping of the swing arm propellant line system.

The applicability of ion pumps to vacuum jacketed propellant lines should be evaluated, since line construction could be simplified by eliminating gettering material and the need for a separate readout device such as a vacuum thermocouple probe.

6.3.5 Analysis

The following data was used to analyze three vacuum system concepts and determine the pump and line sizes needed for each one.

This analysis will determine the vacuum pump and line sizes needed for three (3) vacuum system concepts. The simplest system would be installation of an individual ion vacuum pump in each isolated vacuum line section. An ion vacuum pump appears adequate to accommodate the outgassing that can be anticipated after the line had been previously evacuated with a mechanical and diffusion pump. For excessive outgassing or leakage due to minute leaks, the series or parallel connected vacuum pump down systems, with the combined mechanical and diffusion pump mounted on the tower is needed. The series or parallel connected system will encompass an individual arm. The vacuum pumps will be sized for a central or multiple system. Each propellant will have its own vacuum system, to prevent any possibility of getting an explosive mixture.

This analysis verifies the feasibility of either an ion vacuum pump for each vacuum jacket, a single vacuum pumping system for each propellant arm in either parallel or series connections between vacuum jackets. The ion vacuum pump has the disadvantage of requiring a replacement of its gettering element after long periods of time, although the outgassing rate has also decayed to a lower value. The central station vacuum pump system for all three (3) swing arms is impractical.

ASSUMPTIONS:

1. Mechanical pump size will be based on 5×10^{-2} Torr and the diffusion pump size will be based on 1×10^{-3} Torr (Millimeters of mercury).

2. Vacion pump size will be based on 1×10^{-6} Torr.

3. Assume outgassing rate of aluminum foil and dexter paper at 10^{-6} Torr will equal 6061-T6 aluminum at 1.6×10^{-10} Torr - liter/sec. Ref: Handbook of high vacuum Engineering by Steinherz, Page 8.

4. Outgassing rate for stainless steel at 10^{-6} Torr and 100 hours pumpdown with a bake of 12 hours at $400^{\circ}C$ is 9.3×10^{-13} Torr - Liter/sec. Ref: IBID.

AMETEK / Straza **ENGINEERING REPORT**

SUBJECT: VACUUM PUMPING SYSTEMS

BY: C. Urbanac CHECKED:

NO:

DATE:

PAGE 2 OF 2

JOB NO: 4055

Ion Pump in Line No. 8-030147-1 on Arm #4

$S = \frac{\Sigma KA}{P}$ Ref: Vacuum Technology Lecture Notes - Unpublished - By Drs. R. A. Chuan, D. A. Wallace, K. W. Rogers and F. L. Torney, Jr. - Given at U.C.L.A.

$K_{AL} = 1.6 \times 10^{-10}$ Torr-liter/sec outgassing rate for Aluminum foil and Dexter Paper at 10^{-6} Torr.

$K_{ss} = 9.3 \times 10^{-13}$ Torr-liter/sec. outgassing rate for stainless steel at 10^{-6} Torr.

$A_{AL} = 1.01 \times 10^{5}$ CM^2 area of 10 layers each of Aluminum foil and Dexter Paper.

$A_{ss} = .212 \times 10^{5}$ CM^2 area of line and vacuum jacket.

$P = 10^{-6}$ Torr Line Pressure

$$S = \frac{(1.6 \times 10^{-10})\ 1.010 \times 10^{5} + (9.3 \times 10^{-13})\ .212 \times 10^{5}}{10^{-6} \times 1000 \text{ cc/liter}}$$

$= .0162$ liters/second equivalent pumping speed needed

A one liter/second ion pump will be adequate for line No. 8-030147-1 that is 28" long and also for line No. 8-030149-1 that is 196" long.

$$S_{8-030144-1} = .0162 \times \frac{196}{28}$$

$$= .113 \text{ L/sec} < 1.0 \text{ L/sec}$$

AMETEK / Straza

ENGINEERING REPORT

SUBJECT: VACUUM PUMP SYSTEMS

BY: CHECKED:

NO:
DATE: 5 June 1969
PAGE 0 OF
JOB NO: 4055

SUMMARY:

I Central Vacuum Utility Remote Line #8-030188-1 on Arm 6 - "Pumpdown Time" Ref. Pages 93 through 96.

Size of Manifold	2" Ø	3" Ø	4" Ø
Size of Standpipe	4" Ø	6" Ø	8" Ø
Time In Hours For Mech Pump From 760 To .050 Torr	21.6	15.2	13.9
Time In Hrs For Diff Pump From .050 To .001 Torr	275.0	193.0	176.8

II Multistation Vacuum System Remote Line #8-030188-1 "Pumpdown Time". Ref. Pages 113 through 115.

Size of Manifold	2.0" Ø	4" Ø
Time In Hrs For Mech. Pump From 760 To .050 Torr	5.57	3.01
Time In Hrs For Diff. Pump From .050 To .001 Torr	25.49	13.79

III Central Vacuum Utility Pumpdown Time For Arms 1, 4, & 6 Ref. Pages 97 through 107.

Size of Manifold	4" Ø
Size of Standpipe	8" Ø
Time In Hrs For Mech Pump From 760 To .050 Torr	32.72

III (Continued)

Time In Hrs For Diff. Pump From .050 To .001 Torr	1118.83	

IV Multistation Vacuum System Arm 6 "Pumpdown Time" Pages 108 through 112.

Size of Manifold	2.0" Ø	4" Ø
Time In Hrs For Mech. Pump From 760 To .050 Torrs	25.86	8.17
Time In Hrs For Diff. Pump From .050 To .001 Torrs	329.0	103.41

Time required to pump down the most remote line #8-03088-1 on arm 6 at Sta. 2729. Arm Manifold 2.0" Ø (5.25 CM Ø) and tower standpipe 4.0" Ø (10.23 CM Ø). Assume mechanical or diffusion pump speeds of 100 liter/sec.

$$* \quad \frac{1}{C_{88-1}} = \frac{1}{C_{Annulus}} + \frac{1}{C_{Manifold}} + \frac{1}{C_{Tower}}$$

$$* \quad C_{Annulus} = \frac{100\, r_A^3}{L_A}$$

r_A = 2.58 CM Equiv. Radius of Line Annulus.

L_A = 290 CM Line Lt.

$$= \frac{100\ (2.58)^3}{290} = \frac{17.22}{2.90}$$

$$= 5.94 \text{ L/Sec}$$

$$C_{Manifold} = \frac{100\ (2.625)^3}{2530}$$

L_M = 2530 CM Manifold + Connector length.

$$= .71 \text{ L/Sec}$$

$$C_{Tower} = \frac{100\ (5.12)^3}{6932}$$

L_T = 6932 CM Tower Length

$$= 1.94$$

$$\frac{1}{C_{88-1}} = \frac{1}{5.94} + \frac{1}{.71} + \frac{1}{1.94}$$

$$= .48 \text{ L/Sec}$$

* REF: Cryogenic Engineering By Scott 1^{St} ED page 156 Equations 6.14 and 6.17

Time To Pump Down Most Remote Line #8-03088-1 On Arm 6

Mech. Pump 100 L/S, Range 760 To .050 Torr

$$\frac{1}{S'} = \frac{1}{100} + \frac{1}{.48}$$

$S' = .48$ L/S Equiv. Pump Speed

$$t_{MP} = \frac{K\ V}{S}\ LN\ \frac{P1}{P2}$$

K = 4.0 Outgassing Factor For 760 To .050 Torr

REF: Steinherz "Handbook Of High Vacuum Engrg" P192

K = 1.5 Is Adjusted For Baffle In Line

V_{2+4} = Vol. Of Annulus + 2" Ø Manifold + 4" Ø Standpipe

= 342 + 55 + 571

= 968 L Use 970

P_1 = 760 Torr

P_2 = .05 Torr

$$t_{MP} = 4.0\ \frac{970}{.48}\ LN\ \frac{(760)}{(.05)}\ \frac{1}{3600}$$

= 10.8 Hrs To Pumpdown From 760 To .050 Torr

Time To Pump Down Most Remote Line 8-03088-1 On Arm 6.

Diffusion Pump 100 L/S, Range .050 Torr To 1M

$$t_{dp} = K \frac{V}{S' P_3} (P_2 - P_3)$$

REF: Steinherz "Handbook Of High Vacuum Engineering" P193

K = 5.0 Outgassing Factor For .050 Torr To 1M

P_3 = 10^{-3} Torr = 1M

$$t_{dp} = \frac{5.0 \times 970}{.48 \times 10^{-3}} (.050 - .001) \frac{1}{3600}$$

$$= 137.5 \text{ Hours}$$

Times Required To Pump Down The Most Remote Line #8-03088-1 On Arm 6:

PIPE SIZES

	2" Ø Manifold 4" Ø Standpipe	3" Ø Manifold 6" Ø Standpipe	4" Ø Manifold 8" Ø Standpipe
$C_{Annulus}$ L/S	5.94	5.94	5.94
$C_{Manifold}$ L/S	.71	2.36	5.31
C_{Tower} L/S	1.94	6.59	15.01
ΣC_{88-1} L/S	.52	1.71	3.81
S' L/S	.48	1.34	2.36
V = Vol. Liters	970	1900	3065
t_{mp} Hours Mech. Pump	21.6	15.2	13.9
t_{dp} Hours Diffusion Pump	275.0	193.0	176.8

Time Required To Pump Down Arms 1, 4, & 6 With Pumps At Base Of Tower. (LO_2 Lines)

Summing Overall Conductances At Pumps

$$\frac{1}{C_{Pump}} = \frac{1}{C_{A6 + T6}} + \frac{1}{C_{A4 + T4}} + \frac{1}{C_{A1 + T1}}$$

C_{A6} = .541 L/S For A 4" Ø Manifold

$$C_{T6} = \frac{100\, r^3}{L_6}$$

Let r = 10.68 CM Inside Radius Of An 8" Ø Standpipe

$$= \frac{100\,(10.68)^3}{6932} = \frac{12.18 X 10^4}{6932} \qquad L_6 = 2729\text{" Or } 6932 \text{ CM}$$

= 17.57 L/Sec.

$$\frac{1}{C_{A6 + T6}} = \frac{.541 + 17.57}{.541 \cdot 17.57}$$

$C_{A6 + T6}$ = .52 L/S

LO_2 Lines

Arm 4 + Tower Conductance

$$\frac{1}{C_{A4+T}} = \frac{C_M + C_{47-3}}{C_M \; C_{47-3}} + \frac{C_{M-1} + C_{46-1}}{C_{M-1} \; C_{46-1}} + \frac{C_{M-2} + C_{54-1}}{C_{M-2} \; C_{54-1}} + \frac{C_{M-3} + C_{55\cdot}}{C_{M-3} \; C_{55\cdot}}$$

$$+ \frac{C_{M-4} + C_{56-3}}{C_{M-4} \; C_{56-3}} + \frac{C_{M-5} + C_{57-3}}{C_{M-5} \; C_{57-3}} + \frac{1}{C_{T4}}$$

$$C_M = \frac{100 \, r_M^{\,3}}{L_M}$$ r_M = 5.12 CM Rad. Of 4" Ø Manifold

L_M = LT of Lines #8-030146-1 + 8-030154-1 + 8-030155-3 + 8-030156-3 + 8-030157-3 + 100 CM LT. To Standpipe

= 650 + 307 + 381 + 221 + 373 + 60

= 2032 CM

$$C_M = \frac{100\,(5.12)^3}{2032} = \frac{13422}{2032}$$

= 6.61 L/Sec

$$C_{M-1} = \frac{13422}{L_{M-1}}$$ L_{M-1} = 2032 - 650 = 1382 CM

$$= \frac{13422}{1382}$$

= 9.71 L/Sec

$$C_{M-2} = \frac{13422}{L_{M-2}}$$

$$L_{M-2} = L_{M-1} - 307 = 1382 - 307 = 1075 \text{ CM}$$

$$= \frac{13422}{1075}$$

$$= 12.49 \text{ L/S}$$

$$C_{M-3} = \frac{13422}{L_{M-3}}$$

$$L_{M-3} = L_{M-2} - 381 = 1075 - 381 = 694 \text{ CM}$$

$$= \frac{13422}{.694}$$

$$= 19.34 \text{ L/S}$$

$$C_{M-4} = \frac{13422}{L_{M-4}}$$

$$L_{M-4} = L_{M3} - 221 = 694 - 221 = 473 \text{ CM}$$

$$= \frac{13422}{473}$$

$$L_{M-5} = 100 \text{ CM}$$

$$= 28.38 \text{ L/S}$$

$$C_{M-5} = 3422 / LM-5$$

$$= \frac{23422}{100}$$

$$= 134.22 \text{ L/S}$$

A/S-521-1

$$C_{47-3} = \frac{100\ (r^3)}{L_{47-3}}$$

r = 7.42 CM Equivalent Radius of Line 8-030147-1 Annulus ~ 10.42" Ø X 8.625" Ø

$$= \frac{100\ (7.42)^3}{71} = \frac{40852}{71} \qquad L_{47-3} = 71 \text{ CM}$$

= 575.4 L/S Line 8-030147-3

$$C_{46-1} = \frac{40852}{L_{46-1}} \qquad L_{46-1} = 650 \text{ CM}$$

$$= \frac{40852}{650}$$

= 62.8 L/S Line 8-030146-1

$$C_{54-1} = \frac{40852}{L_{54-1}} \qquad L_{54-1} = 307 \text{ CM}$$

$$= \frac{40852}{307}$$

= 133.1 L/S Line 8-030154-1

$$C_{55-3} = \frac{40852}{L_{55-3}} \qquad L_{55-3} = 381 \text{ CM}$$

$$= \frac{40852}{381}$$

= 107.2 L/Sec Line #8-030155-3

$$C_{56-3} = \frac{40852}{L_{56-3}}$$ $L_{56-3} = 221$ CM

$$= \frac{40852}{221}$$

$= 184.9$ L/S Line #8-030156-3

$$C_{57-3} = \frac{40852}{L_{57-3}}$$ $L_{57-3} = 373$ CM

$$= \frac{40852}{373}$$

$= 109.5$ L/Sec Line #8-030157-3

$$C_{T4} = \frac{100\ rt^3}{L_4}$$ $L_4 = (2729 - 1839)\ 2.54$

$= 2261$ CM

$$= \frac{12.18 \times 10^4}{2261}$$

$= 53.9$ L/S Tower Conductivity From Arm 4 To Pumps

LO_2 Lines - Arm 4 + Tower Length To Pump

$$\frac{1}{C_{A4+T4}} = \frac{6.61 + 575.4}{6.61 \times 575.4} + \frac{9.71 + 62.8}{9.71 \times 62.8} + \frac{12.49+133.1}{12.49\times133.1} + \frac{19.34+107.2}{19.34\times107.2}$$

$$+ \frac{28.38 + 184.9}{28.38 \times 184.9} + \frac{134.22 + 109.5}{134.22 \times 109.5} + \frac{1}{53.9}$$

$$C_{A4+T4} = 2.01 \text{ L/Sec}$$

LO_2 Lines Arm 1 + Tower Length To Pump

$$\frac{1}{C_{A1+T}} = \frac{C_M + C_{59-1}}{C_M \times C_{59-1}} + \frac{C_{M-1} + C_{58-1}}{C_{M-1} \times C_{58-1}} + \frac{C_{M-2} + C_{94-1}}{C_{M-2} \times C_{94-1}} + \frac{C_{M-3} + C_{79-1}}{C_{M-3} \times C_{79-1}} + \frac{1}{C_T}$$

$$C_M = \frac{100\, r^3}{L_M}$$ LET r = 5.12 CM Rad (4" Ø IPS)

LM = LT Of Lines 8-030158-1 + 8-030194-1 + 8-030179-1 + 100C

= 241 + 216 + 472 + 100

= 1029 CM

$$C_M = \frac{13422}{1029}$$

= 13.04 L/S

$$C_{M-1} = \frac{13422}{L_{M-1}}$$

L_{M-1} = L_M - 241
= 1029-241
= 788 CM

$$= \frac{13422}{788}$$

= 17.03 L/S

$$C_{M-2} = \frac{13422}{L_{M-2}} \qquad L_{M-2} = L_{M-1} - 216$$

$$= 788 - 216$$

$$= 572 \text{ CM}$$

$$= \frac{13422}{572}$$

$$= 23.47 \quad \text{L/S}$$

$$C_{M-3} = \frac{13422}{100} \qquad L_{M-3} = 100 \text{ CM}$$

$$= 134.22 \quad \text{L/S}$$

$$C_{59-1} = \frac{100\, r^3}{L_{59-1}}$$

r = 7.42 CM Equivalent Rad of 8-030159-1 Line Annulus

$$= \frac{40852}{678} \qquad L_{59-1} = 678 \text{ CM}$$

$$= 60.25 \quad \text{L/S}$$

$$C_{58-1} = \frac{40852}{241} \qquad L_{58-1} = 241 \text{ CM}$$

$$= 169.51 \quad \text{L/S}$$

$$C_{94-1} = \frac{40852}{216} \qquad L_{94-1} = 216 \text{ CM}$$

$$= 189.13 \quad \text{L/S}$$

$$C_{79-1} = \frac{40852}{L_{79-1}} \qquad L_{79-1} = 472$$

$$= \frac{40852}{772}$$

$$= 52.92 \quad \text{L/S}$$

$$\frac{1}{C_{A1 + T1}} = \frac{13.04 + 60.25}{13.04 \cdot 60.25} + \frac{17.03 + 169.51}{17.03 \cdot 169.51} + \frac{23.47 + 189.13}{13.47 \cdot 189.13}$$

$$\frac{134.22 + 52.92}{134.22 \cdot 52.92} + \frac{764 \times 2.54}{100\ (10.68)^3}$$

$$C_{A1 + T1} = 4.03 \quad \text{L/S}$$

$$\frac{1}{C_{Pump}} = \frac{1}{.52} + \frac{1}{2.01} + \frac{1}{4.03}$$

$$C_{Pump} = .375 \quad \text{L/S}$$

TRY A 50 L/S Pump

$$\frac{1}{S'} = \frac{1}{50} + \frac{1}{.375}$$

S' = .375 L/S Equivalent Pumping Speed Of Central System

Mech Pumpdown Time For Central System With 4" Ø Manifolds & 8" Ø Standpipe Pressure Range From 760 Down To .050 Torr.

$$t_{MP} = \frac{K\ V}{S'} \quad LN \left(\frac{760}{.050}\right)$$

K = 4.0 Outgassing & Baffle Factor For 760 To .05 Torr

V = Volume Of Lines + 4" Ø Manifolds + 8" Ø Tower

$$= \left\{(2.54)^3\ 1728\ (10.06 + 14.425 + 15.053) + \pi\left[\overline{5.12}^2\ (2530 + 2032 + 1029) + \overline{10.68}^2\ (2.54 \times 2729)\right]\right\} /100$$

$$= 113.49 + 460.45 + 2483.88$$

$$= 3057.82 \quad \text{Liters}$$

$$t_{MP} = 4.0 \times \frac{3057.82}{.372} \quad LN \left(\frac{760}{.050}\right) \quad \frac{1}{3600}$$

$$= 32.72 \text{ Hours}$$

DIFFUSION PUMP TIME

$$t_{dp} = \frac{K\ V}{S'\ P_3} (P_3 - P_2)$$

K = 10.0 Outgassing & Baffle Factor For .050 To .001 Torr

P_3 = .001 Torr

$$t_{dp} = 10.0 \times \frac{3057.82}{.372 \times 10^{-3}} (.050 - .001) \frac{1}{3600}$$

= 1118.83 Hours to Pump Down System From .050 To .001 Torr.

AMETEK / Straza

ENGINEERING REPORT

SUBJECT: MULTISTATION VACUUM SYSTEM
ARM 6 PUMPDOWN TIME, 4" Ø MANIFOLD

BY: CHECKED:

NO:
DATE: 4 June 1969
PAGE 16 OF
JOB NO: 4055

Time required to pump down arm 6, with pump mounted at Sta. 2729. Assume Manifold is 4" Ø.

ARM 6 CONDUCTANCE

$$\frac{1}{C_{A6}} = \frac{C_M + C_{88-1}}{C_M \times C_{88-1}} + \frac{C_{M-1} + C_{89-1}}{C_{M-1} \times C_{89-1}} + \frac{C_{M-2} + C_{90-1}}{C_{M-2} \times C_{90-1}} + \frac{C_{M-3} + C_{91-1}}{C_{M-3} \times C_{91-1}} + \frac{C_{M-4} + C_{92-3}}{C_{M-4} \times C_{92-3}} + \frac{C_{M-5} + C_{93-3}}{C_{M-5} \times C_{93-3}}$$

$$C_M = \frac{100\, r^3}{L_M}$$

LET r = 5.12 CM Rad (4.0" Ø Pipe)

L_M = 2.54 (296 + 282 + 87 + 171 + 136)
= 2475 CM Use 2530 CM

$$= \frac{100\,(5.12)^3}{2530} = \frac{13422}{2530}$$

$$= 5.31 \quad \text{L/S}$$

C_{88-1} = 5.94 L/S From Previous Calculations

$$C_{M-1} = \frac{100\,(5.12)^3}{2.54\,(282 + 87 + 171 + 136)} = \frac{13422}{1717}$$

$$= 7.82 \quad \text{L/S}$$

$$C_{89-1} = \frac{1722}{2.54 \times 296}$$

$$= 2.29 \quad \text{L/S}$$

$$C_{M-2} = \frac{13422}{2.54\,(87 + 171 + 136)} = \frac{13422}{1000.76}$$

$$= 13.41 \quad \text{L/Sec}$$

A/S-521-1

$$C_{90-1} = \frac{1722}{2.54\ (282)} = \frac{1722}{716.28}$$

$$= 2.40 \quad L/S$$

$$C_{M-3} = \frac{13422}{2.54\ (171 + 136)} = \frac{13422}{779.78}$$

$$= 17.2 \quad L/S$$

$$C_{91-1} = \frac{1722}{2.54 \times 87} = \frac{1722}{220.98}$$

$$= 7.79 \quad L/S$$

$$C_{M-4} = \frac{13422}{2.54\ (136)} = \frac{13422}{345.44}$$

$$= 38.9 \quad L/S$$

$$C_{92-3} = \frac{1722}{2.54 \times 171} = \frac{1722}{434.34}$$

$$= 3.96 \quad L/S$$

$$C_{M-5} = \frac{13422}{2.54\ (24)} = \frac{13422}{60.96}$$

Here L = 24" Assumed Length Of Manifold To Pump

$$= 220.2 \quad L/S$$

$$C_{93-3} = \frac{1722}{2.54 \times 136} = \frac{1722}{345.44}$$

$$= 4.98 \quad L/S$$

$$\frac{1}{C_{A6}} = \frac{5.31 + 5.94}{5.31 \times 5.94} + \frac{7.82 + 2.29}{7.82 \times 2.29} + \frac{13.41 + 2.40}{13.41 \times 2.40} + \frac{17.2 + 7.79}{17.2 \times 7.79}$$

$$+ \frac{38.9 + 3.96}{38.9 \times 3.96} + \frac{220.2 + 4.98}{220.2 \times 4.98}$$

C_{A6} = .541 L/S With A 4" Ø Manifold

Try A 5.0 L/S Vacuum Pump Speed

$$\frac{1}{S'} = \frac{1}{5.0} + \frac{1}{.541}$$

S' = .49 L/S

Mech. Pump Time To Pump Down From 760 To .05 Torr.

$$t_{MP} = K_{MP} \frac{V}{S'} \text{ LN } \frac{P_1}{P_2}$$

K = 4.0 Outgassing factor Ref: Hd Bk Of Vacuum Engrg By Steinherz, Page 192. Also, includes inefficiency of baffle.

V = Total Line + Manifold Volume

$= \left[(2.54)^3 \ (1728 \times 15.053) + 2530\pi \ (5.12)^2\right] /1000$

= 635 L. For 4" Ø Manifold; 481L For 2" Manifold

P_1 = 760 Torr Initial Line Pressure

P_2 = .050 Torr Final Line Pressure

MECH. PUMP TIME

$$t_{mp} = 4.0 \times \frac{372}{.49} \, LN \left(\frac{760}{.050} \right) \frac{1}{3600}$$

= 8.17 Hours To Pump Down Arm 6 From 760 Torr To .050 Torr With Pump Mounted At Sta. 2729 Adjacent To Arm 6.

DIFFUSION PUMP TIME

$$t_{dp} = K_{dp} \frac{V}{S' \, P_3} (P_2 - P_3)$$

K_{dp} = 10.0 (Outgassing Factor X Pump Baffle Efficiency Factor)

P_3 = .001 Torr Or 1.0M

$$t_{dp} = \frac{10 \times 372}{.49 \times 10^{-3}} (.050 - .001) \frac{1}{3600}$$

= 103.41 Hours To Pump Down Arm 6 From .050 To .001 Torr.

		MANIFOLD PIPE DIA FOR ARM 6	
		2.0" (2.625 CM RAD.)	4.0" (5.12 CM RAD.)
C_{887}	L/S	5.94	5.94
C_M	L/S	.71	5.31
C_{89-1}	L/S	2.29	2.29
C_{M-1}	L/S	1.05	7.82
C_{90-1}	L/S	2.40	2.40
C_{M-2}	L/S	1.81	13.41
C_{91-1}	L/S	7.79	7.79
C_{M-3}	L/S	2.32	17.2
C_{92-3}	L/S	3.96	3.96
C_{M-4}	L/S	5.24	38.9
C_{93-3}	L/S	4.98	4.98
C_{M-5}	L/S	29.67	220.2
C_{A6}	L/S	.207	1.82
S'	L/S	.199	.49
t_{mp}	Hrs.	25.86	8.17
t_{dp}	Hrs.	329.0	103.41

Time Required To Pump Down The Most Remote Line On Arm 6, Assuming A 2" Ø Manifold

Line #8-030188-1 & 2" Ø Manifold

$$C_{88-1} = \frac{100\ r_A{}^3}{L_A}$$

r_A = 7.22 CM Equivalent Radius of Annulus 8.40" Ø X 6.625" Ø on Line #8-030188-1.

$$= \frac{100\ (2.58)^3}{290}$$

L_A = 290 CM Length of Line # 8-030188-1

$$= 5.94 \quad L/S$$

$$C_{Manifold} = \frac{100\ (r_M{}^3)}{L_M}$$

r_M = 2.625 CM Radius of 2.0" IPS Manifold

$$= \frac{100\ (2.625)^3}{2530}$$

L_M = 2530 CM

$$= .71\ L/Sec$$

$$\frac{1}{\Sigma C} = \frac{1}{5.94} + \frac{1}{.71}$$

$$\Sigma C = .633$$

Try A 5.0 L/S Pump Speed & Solve For Equiv. Speed

$$\frac{1}{S'} = \frac{1}{5.0} + \frac{1}{.633}$$

$$S' = .562\ L/Sec$$

Mech. Pump Time To Pump Down From 760 To .050 Torr.

$$t_{mp} = \frac{K\ V}{S'} \quad LN \left(\frac{760}{.050}\right)$$

V = Annulus Volume Of Line 8-030188-1 + Volume of 2" Ø Manifold

$$= (\overline{2.54}^3 \text{ X } 1728 \text{ X } 1.677 + \overline{2.625}^2 \pi \text{ X } 250) \ /1000$$

$$= 47.49 + 54.77$$

$$= 102.26 \text{ L. Vol of 2" Ø Manifold} \quad \text{(L. For 4" Ø)}$$

$$t_{mp} = 4.0 \text{ X } \frac{102.26}{.562} \quad LN \quad \frac{760}{.050} \quad \frac{1}{3600}$$

= Hours For 2" Ø Manifold

Diff. Pump Time To Pump From .050 To .001 Torr

$$t_{dp} = 10.0 \quad \frac{102.26}{.562 \text{ X } 10^{-3}} \quad (.050 - .001) \quad \frac{1}{3600}$$

$$= 24.77 \text{ Hours For 2" Ø Manifold}$$

NO:

SUBJECT: MULTISTATION VACUUM SYSTEM REMOTE LINE #8-030188-1 PUMP DOWN TIME

DATE: 5 June 1969

BY: CHECKED:

JOB NO: 4055

	MANIFOLD PIPE DIA FOR ARM 6	
	2.0" Ø (2.625 CM RAD)	4.0" Ø (5.12 CM RAD)
C_{88-1} L/S	5.94	5.94
C_M L/S	.71	5.31
ΣC L/S	.71	5.10
S' L/S	.562	2.525
V L	105.26	255.85
t_{mp} Hrs. Mech. Pump	5.57	3.01
t'_{dp} Hrs. Diff. Pump	25.49	13.79

6.4 PHASE II TEST PLAN

The following test plan was proposed for Phase II of the Central Vacuum System Study. This Phase was cancelled and consequently was not performed.

The Test Plan is included here as a protion of the requirement of the Phase I Study.

6.4.1 Abstract

During the initial Phase I study, component operation and functional requirements were reviewed with a survey of Complex 39 to determine installation feasibility. No review could be made of existing field hardware since no central drawdown system is presently in use at Cape Kennedy. Coupling experience with vacuum drawdown system analysis indicated that such a system was not only feasible, but also reliable with a minimum of maintenance required.

State-of-the-art review was undertaken with four systems being considered. These were:

A. Single station pumpdown system.

B. Multistation pumpdown system.

C. Vacuum Ion/Absorption pumping system.

D. Vacuum Ion Maintenance pumps.

Analysis of manifold requirements showed that for a single system station the pipe diameter would become prohibitive (up to 12 inches to cover all swing arms) while manifold size on the swing arms themselves would have to be 4 (four) to 5 (five) inches. In the multistation system each swing arm would have a small mechanical/diffusion pump system with a 2 (two) inch diameter manifold. The system would be automatic with isolation valves provided for line failure or power failure. The absorption pump system was discarded mainly because of the need for liquid nitrogen at each swing arm level. The vacuum ion pump system seems to be somewhat feasible with further evaluation of life expectancy by testing.

In the Phase II test program it is envisioned that such a station would be evaluated environmentally and functionally for use at Cape Kennedy. In conjunction with this program an evaluation test would be conducted with the vacuum ion pump system. The diffusion pump system would be obtained from NRC or Varian and the vacuum ion pump would be obtained from Varian. The other sensitive element of the system to be evaluated would be the isolation valves. All other valving, flex hose sections, etc., would be evaluated under other sections of the study program.

A. Scope

The purpose of this document is to set forth the test philosophy and test requirements for a central drawdown system for verifying equipment performance to meet operating conditions at Cape Kennedy.

B. Test Philosophy

Analysis of pumping requirements and manifold size during the Phase I portion of the KSC Study Program for the vacuum technology advancement has shown the multistation pumpdown system to be the most practical. In addition, a promising method of maintaining vacuum ion pumps on individual umbilical lines.

Because such a system is composed of vacuum components such as seal-off valve, vacuum probes, flexible manifold lines which are included in the study program, only selected components will be tested. These are the isolation valves which are electrically operated and the pumping station itself. In addition, a vacuum ion pump will be evaluated for practicability in the special application as a vacuum maintenance pump on the umbilical lines.

C. Description of Test Specimen

Diffusion Pump Station

The pumping station vapor components will be a two (2) inch diffusion pump, a mechanical pump, and a water cooled baffle. The system will be completely automated with controls to allow a single push button operation. Power failure will affect a fail-safe shut down of the system with an automatic cycle to return the system to line effectiveness. The units will be enclosed to provide weather protection.

Isolation Valves

These valves, located at each line segment are basically safety devices being closed during any propellant loading operation. These valves will also close with any failure of a line's vacuum jacket. The construction will be of stainless steel, Series 316, with 1.5 inch ports. The valves will be of the bellows or butterfly type.

Vacuum Ion Pump

The vacuum ion pump will have a one liter/second capacity with a power source with pressure provisions. Body construction will be of stainless steel for corrosion resistance.

D. Applicable Documents

The following document will be used as a guide in testing vacuum probes:

KSC-STD-164D "Environmental Test Methods for Ground Support Equipment Installations at Cape Kennedy", dated September 17, 1964.

6.4.2 Test Plan

6.4.2.1 Test Sequence

Units will be tested as indicated in the following table and in the sequence as shown:

Test	Pumping Station	Isolation Valve	Vacuum Ion Pump
Functional	X	X	X
Proof Pressure		X	X
Temperature & Humidity	X		
Salt Fog	X	X	X
Sand and Dust	X	X	X
Thermal		X	
Vibration	X	X	X
Shock		X	X
Line		X	X

6.4.2.2 Test Procedure

6.4.2.3 Functional Tests

Each type of specimen will receive a functional test as outlined below. Functional tests will be performed after each environmental test to determine any degradation or failure of the part.

A. Vacuum Pump

The following will be the minimum functional test for the vacuum pump station.

(1) Leakage: The leak rate shall not exceed 1×10^{-6} Std cc/sec of He gas as measured with a helium mass spectrometer.

(2) Pumpdown: The unit will be hooked up to a vacuum system with a known leak rate of

6×10^{-6} Std cc/sec and with a volumn of not less than 100 liters. Pumpdown shall be effective to 10 microns or better.

(3) Cycling: While attached to the same vacuum system the pump will be cycled automatically through its sequence.

B. Isolation Valves

(1) Leakage: The leak rate shall not exceed 1×10^{-6} Std cc/sec of He gas as measured with a helium mass spectrometer.

(2) Minimum operating voltage: A minimum operating voltage will be applied to the solenoid to insure satisfactory operation. The valve will be opened and closed ten (10) times.

C. Ion Pumps

(1) Leakage: The maximum leakage of the ion pump will not exceed 1×10^{-6} Std cc/sec of He gas as measured with a helium mass spectrometer.

(2) Operation: The unit will be connected to a vacuum system with a volumn of 100 liters or more. Vacuum level and current will be recorded over an eight (8) hour period.

D. Proof Pressure

The test specimens will be pressurized internally with nitrogen gas to 150 PSIG.

E. Salt Fog

The test specimens will be exposed to a solution of salt, 5 parts by weight in 95 parts by weight of water, at 5°F for a period of 240 ±2 hours. The specimens will be non-operating with protective covers in place.

F. Sand and Dust

The test specimens will be exposed to sand and dust at an air velocity of 100 feet to 500 feet per minute at 77°F for a period of two (2) hours. At the end of this period, the temperature will be raised to 160°F and the condition will be maintained for an additional two (2) hours. The specimens will be non-operating with protective covers in place.

G. Thermal Test

(1) Low Temperature

Each specimen will be placed in an environmental box and the temperature lowered to $-65^{o}F$ and allowed to stabilize. After the specimens are removed from the environmental box, a functional test will be performed.

(2) High Temperature

Each specimen will be exposed to an area of flame at $1400 \pm 100^{o}F$ for a period of ten (10) seconds. A functional test will be performed at the end of the high temperature test.

H. Vibration

Each specimen will be vibrated in accordance with Procedure I of KSC-STD-164.

(1) Sinusoidal Sweep

Maximum g level for the test specimens will be 30 g's sinusoidal. The specimens will be exposed to sinusoidal vibration that is cycled at a logarithmic rate between the frequency limits of 10 and 2000 cycles per second at the specified level. The frequency range shall be traversed once in the direction of increasing frequency and once in the direction of decreasing frequency for a period of 20 minutes (10 minutes up and 10 minutes back). A functional test will be performed after the completion of each axis of vibration.

(2) Random Excitation

The test specimens will be exposed to random vibration at the levels specified over a frequency range from 10 to 2000 cps for a period of five (5) minutes. The specimens will be functionally tested after each axis of vibration.

I. Shock

Each specimen will be shock tested to 30 g's with a pulse deviation of 2 ms. The pulse shape will be one half sine wave and each specimen will be tested along both directions of three (3) mutually perpendicular axes.

J. Accelerated Life Test - Vibration

A life test will be conducted for the isolation valve and the ion pump as follows:

(1) Isolation Valve

The isolation valve will be cycled 500 times for the life test. Each cycle will consist of opening the valve to a vacuum and allowing a small chamber on the oposite side of the valve to be evacuated. The valve will then be closed and the chamber allowed to return to atmospheric pressure. After every fifty (50) cycles, the valve will be tested for leakage with a helium mass spectrometer.

(2) Ion Pump

The vacuum ion pump will be connected to a chamber containing the equivalent aluminum and dexter paper of a vacuum jacketed line in addition to a constant leak rate into the line of 1×10^{-6} Std cc/sec of air. This system will be allowed to operate as long as practical or until pump failure. Chamber pressure will be monitored to extrapolate life expectancy.

6.4.3 Documentation

A test log shall be kept by the test engineer, listing the following minimum information and any other deemed pertinent.

A. Date of test and specimen identification.

B. Names of testing personnel and others present to observe the test.

C. A brief description of test set up.

D. Test results, damage, condition of specimen as compared to the condition prior to test.

E. Any circumstances or conditions which might affect test results in any way.

Both test engineer and project engineer shall sign the test log entries after test.

Photographic evidence (Polaroid, if possible) shall be made of the specimen following each individual test. The photographs shall be identified with date, type of test, specimen identification and any unusual conditions present.

A test report which will include all foregoing information will be generated by the project engineer. This report will include all facts and conclusions, obvious and otherwise which the tests generated. In addition, this report will contain a section entitled "Recommendations". This section will contain the collective suggestions of AMETEK/Straza regarding further design improvements which are a result of the test program.

6.4.4 Procurement Plan

Procurement shall be made for three (3) areas of test evaluation as follows:

A. One (1) automated two (2) inch mechanical/diffusion pump system for environmental and operational tests.

B. Two (2) isolation valves for environmental and operational tests.

C. One (1) one liter/sec vacuum ion pump for evaluation.

A procurement specification will be written for the automated pumping station and submitted to various companies for bid. Two (2) types of isolation valves will be selected from two (2) different companies for evaluation, while the vacuum ion pump will be purchased from Varian Associates.

Hardware Procurement

Hardware	Vendor
Pumping Station (1)	To be determined
Isolation Valves (2)	To be determined
Ion Pump with Power Source	Varian Associates

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